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ENVIRONMENTAL AND EXPLORATION PROGRAM

SUMMARY REPORT # 7

(Through May 31, 1976)

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U. S. DEPARTMENT OF THE INTERIOR

PROTOTYPE OIL SHALE LEASING PROGRAM

TRACT C-b

SUMMARY REPORT #7

(Through May 31, 1976)

Submitted to:

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
Conservation Division
U. S. Geological Survey
Grand Junction, Colorado

By:

C-b Shale Oil Project

Ashland Oil, Inc.
Shell Oil Company, Operator

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TRACT C-b
SUMMARY REPORT #7
(Through May 31, 1976)

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INTRODUCTION

Summary Report #7 and *Quarterly Data Report #7* cover the seventh quarter of exploration and environmental data for the Environmental Baseline Program of Tract C-b. These reports specifically cover the spring quarter of March 1975 through May 1976. *Quarterly Data Report #7* consists of three volumes of the comprehensive data collected for Tract C-b and submitted to the Area Oil Shale Supervisor in Grand Junction on July 15, 1976. The purpose of *Summary Report #7* is to provide the reader with a general overview of the information included in *Quarterly Data Report #7*. For a complete review of Tract activities to date, reports from all quarters must be consulted. Parties interested in the project can review these volumes by contacting the Area Oil Shale Supervisor's Office. For ready reference, the reader is reminded that both outline and section numbering in summary and quarterly data reports are identical.

The Revegetation Study Section of this report contains four full-color reproductions showing the progress made in the revegetation of spent shale. With proper treatment spent shale can be most productive. A synopsis of the program is presented with the pictures.

I

PRE-EXPLORATION ENVIRONMENTAL RECONNAISSANCE SURVEYS

No environmental reconnaissance surveys were conducted during this quarter. The results of previous surveys are contained in _Quarterly Data Reports #1 and #2_ and are summarized in _Summary Reports #1 and #2_.

ENVIRONMENTAL BASELINE MONITORING PROGRAMS

II A HYDROLOGY AND WATER QUALITY

II A-1 Surface Water

In this quarter some information was reported for some of the 13 surface water gauging stations shown in Figure II A-1. The data are preliminary and are subject to revision. They encompass the water year beginning September 30, 1975. Tables presenting the various information and printouts may be found in Quarterly Data Report #7. They are grouped by water gauging stations and identified in Table II A-1. Summaries for the major stations are presented in Tables II A-2 through II A-6. At several stations little or no flow has been recorded since the beginning of the 1976 water year. These stations are:

09306015	Flow only on four days in February and three days in March.
09306028	Flow only on 13 days in February and four days in March.
09306033	Flow only on four days in February and three days in April.
09306036	No flow.
09306039	Flow only on ten days in February and nine days in March.
09306042	Flow only on two days in February.
09306050	Flow only on seven days in March.
09306052	Flow only on four days in February and two days in March.

Preliminary precipitation data for 1975 and the first five months of 1976 are also presented in Quarterly Data Report #7. There is no apparent correlation between the precipitation and flow gauged at the associated station.

Water quality at Station 09306025, on the west fork of Stewart Gulch, was significantly different for the samples taken on February 10 and 12, 1976. Nine new minimum concentrations were established and six new maximums were established at this station (Table II A-7). It is interesting

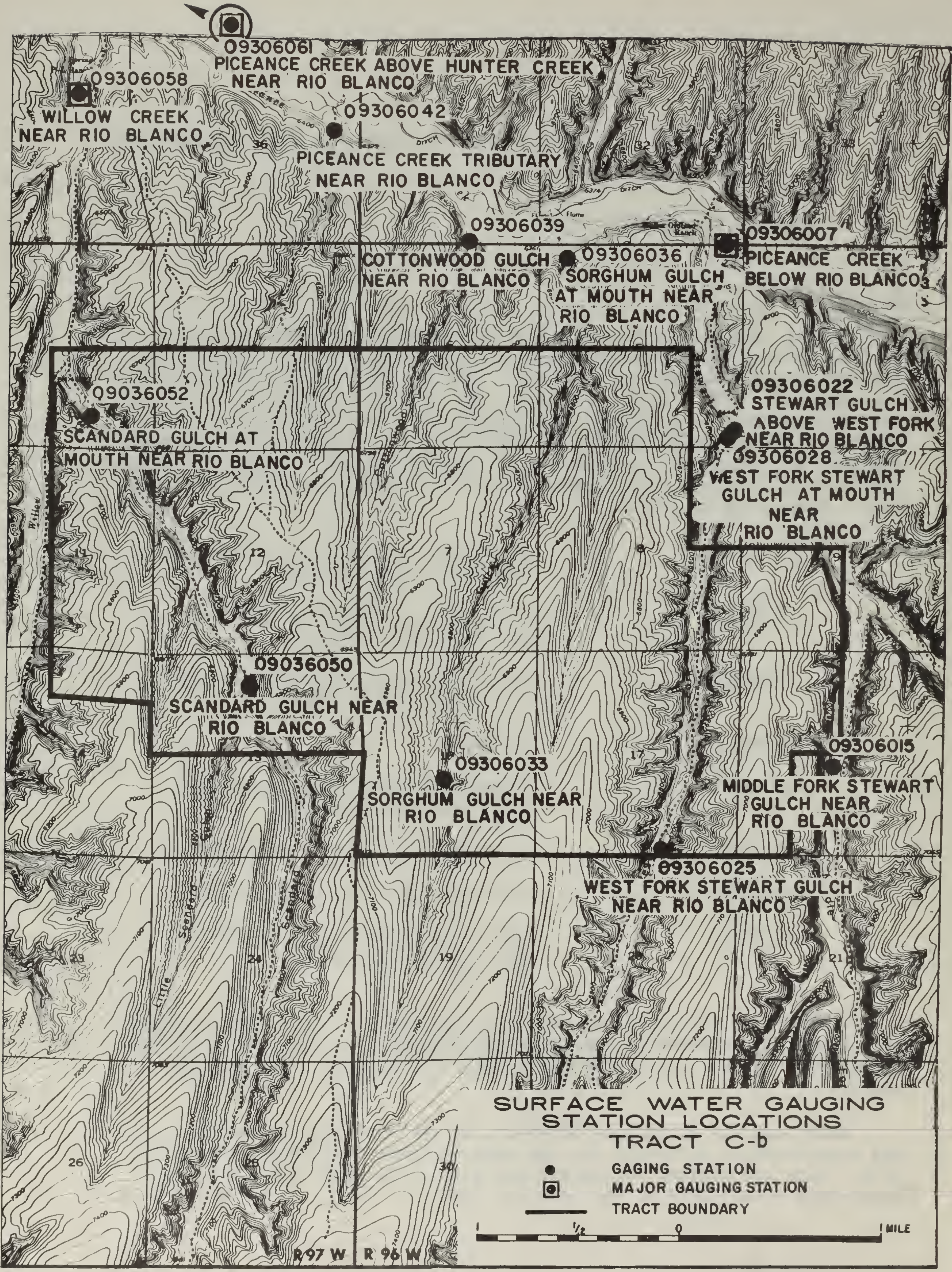

SURFACE WATER GAUGING STATION LOCATIONS
TRACT C-b
● GAGING STATION
⊡ MAJOR GAUGING STATION
TRACT BOUNDARY
1 1/2 0 1 MILE
09306061
PICEANCE CREEK ABOVE HUNTER CREEK NEAR RIO BLANCO
09306058
WILLOW CREEK NEAR RIO BLANCO
09306042
PICEANCE CREEK TRIBUTARY NEAR RIO BLANCO
09306039
COTTONWOOD GULCH NEAR RIO BLANCO
09306036
SORGHUM GULCH AT MOUTH NEAR RIO BLANCO
09306007
PICEANCE CREEK BELOW RIO BLANCO
09036052
SCANDARD GULCH AT MOUTH NEAR RIO BLANCO
09306022
STEWART GULCH ABOVE WEST FORK NEAR RIO BLANCO
09306028
WEST FORK STEWART GULCH AT MOUTH NEAR RIO BLANCO
09036050
SCANDARD GULCH NEAR RIO BLANCO
09306033
SORGHUM GULCH NEAR RIO BLANCO
09306015
MIDDLE FORK STEWART GULCH NEAR RIO BLANCO
09306025
WEST FORK STEWART GULCH NEAR RIO BLANCO
R 97 W
R 96 W

FIGURE II A-1

TABLE II A-1

SURFACE WATER DATA PRESENTED
QUARTERLY REPORT # 7

Station	Daily Gauge Height	Daily Mean Sediment & Discharged Data	Dissolved Oxygen	pH Readings	Specific Conductance	Temperature	Turbidity Values	Sediment Concentrations	Specific Conductance From PS-69 Samples	Temp, pH, D.O. & Conductivity PS-69 Samples	Water Quality Data Process Date 6-7-76
09306007*	x		x	x	x	x		x			x
09306015	x				x	x					x
09306022*	x		x	x	x	x		x			x
09306025	x				x	x		x			x
09306028	x										
09306033	x										x
09306036	x										
09306039	x				x	x					
09306042	x										
09306050	x										
09306052	x										
09306058*	x		x	x	x	x		x			x
09306061*	x		x	x	x	x		x			x

*major gauging station.

Table II A- 2

SURFACE WATER QUALITY
BASELINE DATA

STATION: U. S. G. S. No. 09306007 Piceance Creek Below Rio Blanco Co.

		1974 - 1975			1976 Water Year							
	n	mean	min	max	10/8	10/31	11/17	12/16	1/6	2/26	3/16	4/12
1. Ammonia (mg/1) (Nitrogen)	20	.04	.00	.13	.02	.02	.02	.13	.09	.03	.03	.00
2. Arsenic (ug/1)	42	2	0	5	2	2	2	2	34*	2		
3. Barium (ug/1)	41	<87	0	200	100	200	300*	100			200	
4. Bicarbonate (mg/1)	44	528	390	617	503	552	500	505	402	477	458	409
5. Boron (ug/1)	41	218	110	330	230	200	210	200	180	190	210	130
6. Cadmium (ug/1)	40	<1	0	<15	0	0	-	1			1	
7. Calcium (mg/1)	45	69	51	79	64	73	63	64	69	70	67	63
8. Carbonate (mg/1)	33	1.3	0	32	0	0	0	0	7	0	0	0
9. Chloride (mg/1)	45	15	9	24	15	16	13	13	13	14	13	10
10. Chromium (ug/1)	19	<6	0	90	0	0	-	0			0	
11. Color (PCU)					13	10	8	1	2	5	4	30
12. Copper (ug/1)	40	3	0	12	2	1	-	0			2	
13. Cyanide (mg/1)	20	.00	.00	.02	.0	.0	-	.0			.00	
14. Fluoride (mg/1)	45	1.0	.2	1.3	.8	.8	1.0	1.1	1.1	1.0	1.0	.6
15. Iron (ug/1)	45	70	0	390	50	70	20	10	10	30	-	-
16. Kjeldahl Nitrogen (mg/1)	20	.87	.25	4.0	-	-	.45	.29	.40	.39	1.1	.46
17. Lead (ug/1)	40	<3	0	<16	3	2	-	3				
18. Lithium (ug/1)	40	7	0	20	10	5	20	10			20	
19. Magnesium (mg/1)	45	47	34	57	47	45	43	44	110*	110	110	85
20. Manganese (ug/1)	44	105	10	230				60			50	
21. Mercury (ug/1)	40	<.1	.0	.8	.0	.0	-	.1			.0	
22. Nitrate (mg/1) as NO_3	20	1.4	.22	3.7								
23. Nitrite (mg/1) as NO_2	20	.03	.00	.13								
24. Odor	25	0	0	0								
25. Oil & Grease (mg/1)	19	2.7	0	10	0	0	-	0			1	
26. Ortho-Phosphorus (mg/1) (P)	20	.04	.01	.11	.0*	.02	.01	.03	.02	.01	.01	.01
27. Potassium (mg/1)	45	3.7	2.4	19	3.3	3.7	2.6	2.3*	2.5	3.0	2.8	3.0
28. Selenium (ug/1)	42	1	0	2	1	-	-	1				
29. Silica (mg/1)	45	15	3.4	18	16	16	15	16	14	14	14	13
30. Sodium (mg/1)	45	125	75	160	130	130	120	120				
31. Solids, Dissolved (mg/1)	44	706	502	829	705	728	668	663	614	644	628	552
32. Sulfate (mg/1)	45	160	110	200	180	170	160	150	150	150	150	140
33. Sulfide (mg/1)	20	.2	.0	.9	.2	.0	-	.0			.0	
34. Turbidity (JTU)	20	54.9	0	480								
35. Zinc (ug/1)	40	19	0	60	10	0	0	10			0	
36. pH	44	8.1	6.9	9.0	8.4	8.2	8.4	8.7	8.5	8.2	8.2	8.4

*New Extreme

Table II A- 3

SURFACE WATER QUALITY
BASELINE DATA

STATION: U. S. G. S. No. 09306022 Stewart Gulch Ab West Fork Nr Rio Blanco Co.

		1974 - 1975			1976 Water Year									
	n	mean	min	max	10/7	10/31	11/17	12/16	1/13	2/26	3/16			
1. Ammonia (mg/1) (Nitrogen)	20	.02	.00	.09	.03	.01	.0	.01	.03	.00	.03			
2. Arsenic (ug/1)	33	1.0	0	4	1	1	1	1	1	1	-			
3. Barium (ug/1)	30	<75	0	<200	100	0		200*			0			
4. Bicarbonate (mg/1)	30	505	427	782	479	520	518	466	487	453	433			
5. Boron (ug/1)	30	103	30	530	90	200	80	90	80	80	180			
6. Cadmium (ug/1)	30	<1	0	3	0	0	-	1			1			
7. Calcium (mg/1)	30	93	73	99	95	91	98	97	96	94	92			
8. Carbonate (mg/1)	20	2	0	38	0	0	0	0	0	0	0			
9. Chloride (mg/1)	30	7.5	6	16	7.2	6.5	6.8	5.8*	6.8	6.7	6.2			
10. Chromium (ug/1)	20	<4	0	20	0	4	-	0			10			
11. Color (PCU)					5	2	2	1	1	1	2			
12. Copper (ug/1)	30	2.0	0	8	1	1	-	5			1			
13. Cyanide (mg/1)	20	.0	.00	.02	.0	.0	-	.0			.00			
14. Fluoride (mg/1)	30	.4	.1	3.3	.2	.2	.3	.2	.3	.3	.2			
15. Iron (ug/1)	30	87	0	1200	30	40	20	0	20	20	-			
16. Kjeldahl Nitrogen (mg/1)	20	.53	.14	3.5	-	-	.08	.02*	.23	.40	.46			
17. Lead (ug/1)	30	3	0	7	2	0	-	2			8			
18. Lithium (ug/1)	30	8	0	40	10	5	-	0			10			
19. Magnesium (mg/1)	30	76	64	95	77	76	74	72	77	74	75			
20. Manganese (ug/1)	30	10	0	57	-	-	-	20			<20			
21. Mercury (ug/1)	30	<.1	.0	.4	.0	.0	-	.2			.0			
22. Nitrate (mg/1) as NO_3	20	6.7	.22	8.4										
23. Nitrite (mg/1) as NO_2	20	.02	.00	.13										
24. Odor	30	0	0	0										
25. Oil & Grease (mg/1)	20	3	0	9	0	0	-	0			0			
26. Ortho-Phosphorus (mg/1) (P)	20	.03	.01	.18	.0*	.02	.02	.02	.00	.01	.00			
27. Potassium (mg/1)	30	1.7	1.1	2.5	1.3	1.5	1.3	1.4	1.4	1.4	1.4			
28. Selenium (ug/1)	30	1	0	2	1	2	-	1			1			
29. Silica (mg/1)	30	15	11	17	15	14	14	15	14	15	15			
30. Sodium (mg/1)	30	128	120	250	130	120	120	120	120	120	120			
31. Solids, Dissolved (mg/1)	30	951	865	1160	968	892	949	921	926	914	873			
32. Sulfate (mg/1)	30	370	330	490	400	320*	370	370	360	370	340			
33. Sulfide (mg/1)	20	.13	.0	.7	.5	.0	-	.0			.0			
34. Turbidity (JTU)	20	11	0	30										
35. Zinc (ug/1)	30	31.0	0	370	10	0	0	0			0			
36. pH	30	8.2	7.2	8.8	7.9	8.0	8.2	8.6	8.5	8.2	8.3			

*New Extreme

Table II A-4

SURFACE WATER QUALITY
BASELINE DATA

STATION: U. S. G. S. No. 09306025, West Fork Stewart Gulch Near Rio Blanco Co.

		1974 - 1975			1976 Water Year									
	n	mean	min	max	10/7	11/17	2/10	2/12						
1. Ammonia (mg/1) (Nitrogen)	9	.01	.00	.03	.13*	.00	.05	-						
2. Arsenic (ug/1)	29	1.	0	3	0	1	1	0						
3. Barium (ug/1)	28	<.56	0	220	100									
4. Bicarbonate (mg/1)	30	524	438	757	508	378*	69*	151						
5. Boron (ug/1)	28	107	40	160	90	70	100	100						
6. Cadmium (ug/1)	28	1	0	2	1									
7. Calcium (mg/1)	30	90	48	130	84	57	17*	28						
8. Carbonate (mg/1)	21	1	0	13	0	0	0	0						
9. Chloride (mg/1)	30	10.4	6.5	29.0	11	6.8	2.0*	5.7						
10. Chromium (ug/1)	9	3	0	20	0									
11. Color (PCU)					10	12	45	130						
12. Copper (ug/1)	28	3	0	8	1									
13. Cyanide (mg/1)	9	.00	.00	.01	.00									
14. Fluoride (mg/1)	30	.2	.0	1.2	.2	.2	.1	.1						
15. Iron (ug/1)	30	57	0	220	100	100	210	230*						
16. Kjeldahl Nitrogen (mg/1)	9	.50	.12	1.3	-	.44	1.4	2.0*						
17. Lead (ug/1)	28	3	0	<20	2									
18. Lithium (ug/1)	28	5	0	20	10									
19. Magnesium (mg/1)	30	96	74	120	98	67*	3.1*	16						
20. Manganese (ug/1)	30	5	0	20										
21. Mercury (ug/1)	29	.1	.0	.9	.0									
22. Nitrate (mg/1) as NO_3	9	.80	.00	5.7										
23. Nitrite (mg/1) as NO_2	9	.02	.00	.03										
24. Odor	15	0	0	2										
25. Oil & Grease (mg/1)	9	1	0	2										
26. Ortho-Phosphorus (mg/1) (P)	9	.01	.00	.04	.00	.00	.14	.26*						
27. Potassium (mg/1)	30	3.1	.9	9.8	3	3.9	4.6	12*						
28. Selenium (ug/1)	29	.5	0	5	0									
29. Silica (mg/1)	30	13.6	2.8	18	12	8.8	2.5*	5.4						
30. Sodium (mg/1)	30	158	130	220	150	110*	3.5*	24						
31. Solids, Dissolved (mg/1)	30	1086	943	1450	1120	782*	74*	239						
32. Sulfate (mg/1)	30	490	380	590	510	340*	4.4*	70						
33. Sulfide (mg/1)	9	.1	.0	.2	.3									
34. Turbidity (JTU)	9	8	1	16										
35. Zinc (ug/1)	28	15	0	40	10									
36. pH	28	8.3	7.4	8.9	8.5	-	8.3	8.8						

*New Extreme

Table II A-5

SURFACE WATER QUALITY
BASELINE DATA

STATION: U. S. G. S. No. 09306058 Willow Creek Near Rio Blanco Co.

	1974 - 1975				1976 Water Year									
	n	mean	min	max	10/8	11/3	12/17	1/21	2/25	3/17				
1. Ammonia (mg/1) (Nitrogen)	11	.02	.00	.11	.02	.01	.01	.04	.00	.03				
2. Arsenic (ug/1)	24	1.3	0	4	1	1	1	1	0	-				
3. Barium (ug/1)	26	<55	0	200	0	100	200	100	200	0				
4. Bicarbonate (mg/1)	28	492	444	570	486	502	497	468	426	443				
5. Boron (ug/1)	26	118	70	140	120	100	110	90	100	140				
6. Cadmium (ug/1)	26	<1	0	6	1	0	1	0	1	1				
7. Calcium (mg/1)	28	92	64	100	94	92	94	94	100	95				
8. Carbonate (mg/1)	24	2	0	46	0	0	0	0	26	0				
9. Chloride (mg/1)	28	11.3	9.8	14	13	8.2*	8.8	29*	11	9.2*				
10. Chromium (ug/1)	13	<6	0	40	0	0	0			0				
11. Color (PCU)	11	5	3	9	5	3	2*	3	2	2				
12. Copper (ug/1)	26	<3	0	17	2	1	1			2				
13. Cyanide (mg/1)	11	.00	.00	.01	.00	.00	.00	.00	.00	.00				
14. Fluoride (mg/1)	28	.4	.3	1.3	.4	.4	.5	.4	.4	.3				
15. Iron (ug/1)	29	33	10	150	40	30	10	10	10	-				
16. Kjeldahl Nitrogen (mg/1)	11	.82	.12	3.5	-	-	.76	.21	.20	.31				
17. Lead (ug/1)	26	<3.4	0	<20	3	2	1			3				
18. Lithium (ug/1)	26	6	0	10	10	5	0			10				
19. Magnesium (mg/1)	28	78	68	87	74	72	71	67*	69	69				
20. Manganese (ug/1)	29	13	0	50										
21. Mercury (ug/1)	15	<.1	.0	.2	.0	.0	.0			1.0*				
22. Nitrate (mg/1) as NO_3	11	1.3	.62	2.1										
23. Nitrite (mg/1) as NO_2	11	.02	.00	.03										
24. Odor	29	0	0	0										
25. Oil & Grease (mg/1)	11	2	0	3	0	0	0	0	0	0				
26. Ortho-Phosphorus (mg/1) (P)	11	.02	.01	.10	.00*	.01	.17*	.00	.01	.00				
27. Potassium (mg/1)	28	2.3	1.1	5.0	3.2	2.4	1.7	1.4	1.7	1.7				
28. Selenium (ug/1)	27	1	0	2	1	0	1			1				
29. Silica (mg/1)	28	16	12	18	15	14	15	14	16	15				
30. Sodium (mg/1)	28	130	110	180	120	110	120	110	110	110				
31. Solids, Dissolved (mg/1)	28	952	860	1150	901	868	910	862	870	814*				
32. Sulfate (mg/1)	28	366	310	500	340	320	350	310	320	290*				
33. Sulfide (mg/1)	11	.1	.0	.2	.3	.0	-	.0	-	.0				
34. Turbidity (JTU)														
35. Zinc (ug/1)	26	14	0	40	10	4	0			0				
36. pH	27	8.2	7.8	9.4	8.5	8.7	8.9	8.4	8.4	8.5				

*New Extreme

Table II A-6

SURFACE WATER QUALITY
BASELINE DATA

STATION: U. S. G. S. No. 09306061, Piceance Creek above Hunter Creek Near Rio Blanco Co.

		1974 - 1975			1976 Water Year									
	n	mean	min	max	10/8	11/3	12/18	1/12	2/25	3/17				
1. Ammonia (mg/1) (Nitrogen)	19	.03	.00	.09	.02	.04	.02	.03	.04	.04				
2. Arsenic (ug/1)	40	2	0	6	3	1	2	2	1	-				
3. Barium (ug/1)	41	<70	0	<200	0	100	200*			200				
4. Bicarbonate (mg/1)	42	582	443	690	602	546	537	495	309*	471				
5. Boron (ug/1)	41	200	120	320	200	200	160	140	140	200				
6. Cadmium (ug/1)	41	<1	0	6	0	1	0			1				
7. Calcium (mg/1)	42	77	59	88	84	85	82	80	85	80				
8. Carbonate (mg/1)	31	2	0	39	0	0	0	0	85*	0				
9. Chloride (mg/1)	42	13	11	16	15	13	11	13	13	11				
10. Chromium (ug/1)	21	<4	0	40	0	0	0			0				
11. Color (PCU)	17	9	0	30	5	10	4	3	7	5				
12. Copper (ug/1)	41	<4	0	20	2	2	1			2				
13. Cyanide (mg/1)	19	.00	.00	.03	.00	.00	.00			.00				
14. Fluoride (mg/1)	42	.7	.3	1.5	.5	.8	.7	.6	.6	.6				
15. Iron (ug/1)	44	<65	<2	880	20	20	.0*	20	20	-				
16. Kjeldahl Nitrogen (mg/1)	19	1.12	.21	4.0	-	-	.24	.31	.48	.42				
17. Lead (ug/1)	41	<3	0	20	2	0	1			2				
18. Lithium (ug/1)	41	9	0	20	10	10	10			0				
19. Magnesium (mg/1)	42	68	46	88	83	56	64	62	63	61				
20. Manganese (ug/1)	44	65	0	150	-	-	40	30						
21. Mercury (ug/1)	40	.03	.0	<.1	.0	.0	.1*			.0				
22. Nitrate (mg/1) as NO_3	19	2.3	.35	3.5										
23. Nitrite (mg/1) as NO_2	19	.02	.00	.03										
24. Odor	0	0	0	0										
25. Oil & Grease (mg/1)	19	4	0	9	0	0	0			1				
26. Ortho-Phosphorus (mg/1) (P)	42	.03	.00	.08	.01	.03	.04	.01	.02	.00				
27. Potassium (mg/1)	42	3.7	1.2	6.4	3.4	3.9	2.5	2.4	3.0	2.8				
28. Selenium (ug/1)	40	1	0	2	1	1	1			1				
29. Silica (mg/1)	42	17	12	20	16	16	16	15	15	15				
30. Sodium (mg/1)	42	152	100	200	160	120	140	120	120	120				
31. Solids, Dissolved (mg/1)	42	913	639	1090	1010	817	867	823	835	798				
32. Sulfate (mg/1)	42	290	170	380	350	250	280	280	290	270				
33. Sulfide (mg/1)	19	.2	.0	.5	.2	.0	.0			.0				
34. Turbidity (JTU)	19	100	3	670										
35. Zinc (ug/1)	41	<15	0	50	10	6	0			0				
36. pH	41	8.2	7.5	9.2	7.7	8.6	8.7	8.5	-	8.3				

Table II A-7 NEW EXTREME CONCENTRATIONS
FOR SELECTED PARAMETERS
U.S.G.S. STATION 09306025
WEST FORK STEWART GULCH
TRACT C-b COLORADO

Parameter	2/10/76	2/17/76	Previous Extreme @025	Extreme @ all Stations
		New Minimums*		
Silica	2.5	5.4	2.8	2.8
Calcium	17	28	48	48
Magnesium	3.1	16	67	34 @007
Sodium	3.5	24	110	75 @007
Bicarbonate	69	151	378	378
TDS	74	239	782	502 @007
Specific Cond.	110	360	1160	--
Sulfate	4.4	70	340	110 @007
Chloride	2.0	5.7	6.5	5.8 @022
		New Maximums*		
Iron	210 µg/1	230 µg/1	220 µg/1	1200 µg/1 @022
Aluminum	50 µg/1	110 µg/1	--	--
Potassium	46	12	9.8	19 @007
Kjeldahl Nitrogen	1.4	2.0	1.3	4.0 @007 & 061
Ortho-phosphorus	.14	.26	.04	.18 @022
Color	45 PCU	130 PCU	45 PCU	30 PCU @061
Dissolved Oxygen	15.6	11.0	13.5	--

*mg/1 unless noted.

to note that all the new minimums occurred on the first day, February 10; and while some first day readings established maximums (e.g., orthophosphorus) new maximum readings were made again on the second day, February 12. These anomalous readings are attributed to the high discharge on February 10, 0.27 cfs, brought about by a localized rainstorm coincident with winter snowmelt.

Maximum discharges of 0.15 cfs on October 30, 1974 and of 0.13 cfs on November 6, 1974 had established previous minimum concentrations for calcium and total dissolved solids and maximum concentrations for potassium and iron. The minimum readings are more easily explained (e.g., dilution) than the maximums, some of which are probably related to the flushing away of the products of surficial mechanical and chemical weathering on the Glendive soil series which covers the valley floor. This is a good example of a relationship between various elements in the environment. During the preceding months precipitation was either snow, which during the cold months did not provide runoff, or of insufficient quantity to cause runoff. Thus, with no overland flow to entrain and transport silt and clay-sized particles, to wash away chemical patinas, or take into solution products of weathering as they formed, there was a build up of fine materials and chemical compounds on the surface of the soils.

Thus, when a combination of weather conditions provided an air temperature greater than freezing to initiate snowmelt and rainfall precipitation event to enhance snowmelt, thus contributing to the local supply of water, there was sufficient water to cause overland flow. The previous cold weather had been sufficient to freeze the ground and, except for a few inches below the surface, the soil could be considered impermeable and would not allow infiltration of this runoff. With the infiltration reduced or eliminated, the only release was overland flow to the established stream channel.

During overland flow the fine clay and silt particles were entrained and chemical compounds were taken into solution. The sediment would also serve to cloud and color the water. Chemical compounds and patinas that formed on or near the soil's surface would likely be oxides of the most dominant and reactive elements in the soil.

The Glendive sandy loam has the highest iron and potassium content of all the soils mapped and analyzed in the Tract C-b study area. It also has a high phosphorus content but not the highest. Sodium, sulfate, and chloride are in the high range but the exchange capacity of the soil is low. Percolation through the soil would have been limited by the shallow depth of the thawed soil reducing the possibility of taking the major ions into solution and eliminating the solution of silica.

Recent chemical analysis of two samples of snow obtained on the C-b Tract show a Kjeldahl nitrogen content of 1.3 and 1.8 mg/l. The snowmelt could have increased the total Kjeldahl nitrogen content of the water and been responsible for the maximum reading.

The ion content of the runoff would resemble that of precipitation rather than the typical flow in West Stewart Gulch which is attributed to seeps of ground water. The entrainment of clay-sized particles and consequent solution of surface oxides could contribute to the higher aluminum, iron, and potassium analysis. Turbulance in the overland flow and in the channel of West Stewart Gulch would charge the runoff with a high dissolved oxygen content.

The above speculation includes circumstances involving climatic processes to initiate the phenomenon. Hydrogeomorphic processes acting on a soil that had been subjected physical and chemical weathering created the situation to provide the new extremes in water chemistry at this localized spot in the hydrologic cycle of the Piceance Basin.

II A-2 Springs and Seeps

In Quarterly Data Report #7 water quality analyses are reported for two springs, S-3 and S-9, and for snowmelt samples taken at the location for Cb-2 and SG-18. These data are for samples obtained in February according to the 1976 Ground Water Sampling Program (see Quarterly Summary Report #6, p. 15). The data from the springs do not indicate any anomalous conditions. Some properties of the snowmelt samples are discussed in the preceding section.

II A-3 Ground Water

Ground Water Levels

Water level records for the sixth and seventh quarters are given in Table II A-8. Four wells, SG-8, SG-10, SG-11, and SG-17 were recompleted during the fifth quarter as reported in the fifth quarterly data and summary reports. The First Annual Summary and Trends Report contains potentiometric maps for the upper and lower aquifers. The patterns shown have been generally maintained during the latest period of water level monitoring although there have been changes in the water level elevations. To identify trends in the upper and lower aquifers, maps showing changes in water level during the past three quarters were prepared (Figures II A-2 through II A-7). During August through November 1975, the water level in the upper aquifer fell; from November 1975 through May 1976, water levels have risen. Water levels in the ensuing months will be watched to detect any possible seasonal effects. In general it would be expected that water level fluctuations in the upper aquifer should be related to the areal and time distribution of natural ground water recharge.

Water level fluctuations in the lower aquifer appear to be unrelated to those in the upper aquifer. The water levels have been consistently rising in some areas. This prompted an examination as to whether the several uncompleted core holes in the tract area that connect both upper and lower aquifers could be affecting the water levels.

TABLE II A-8
Summary of Ground Water Levels
(Reduced Levels in Feet)

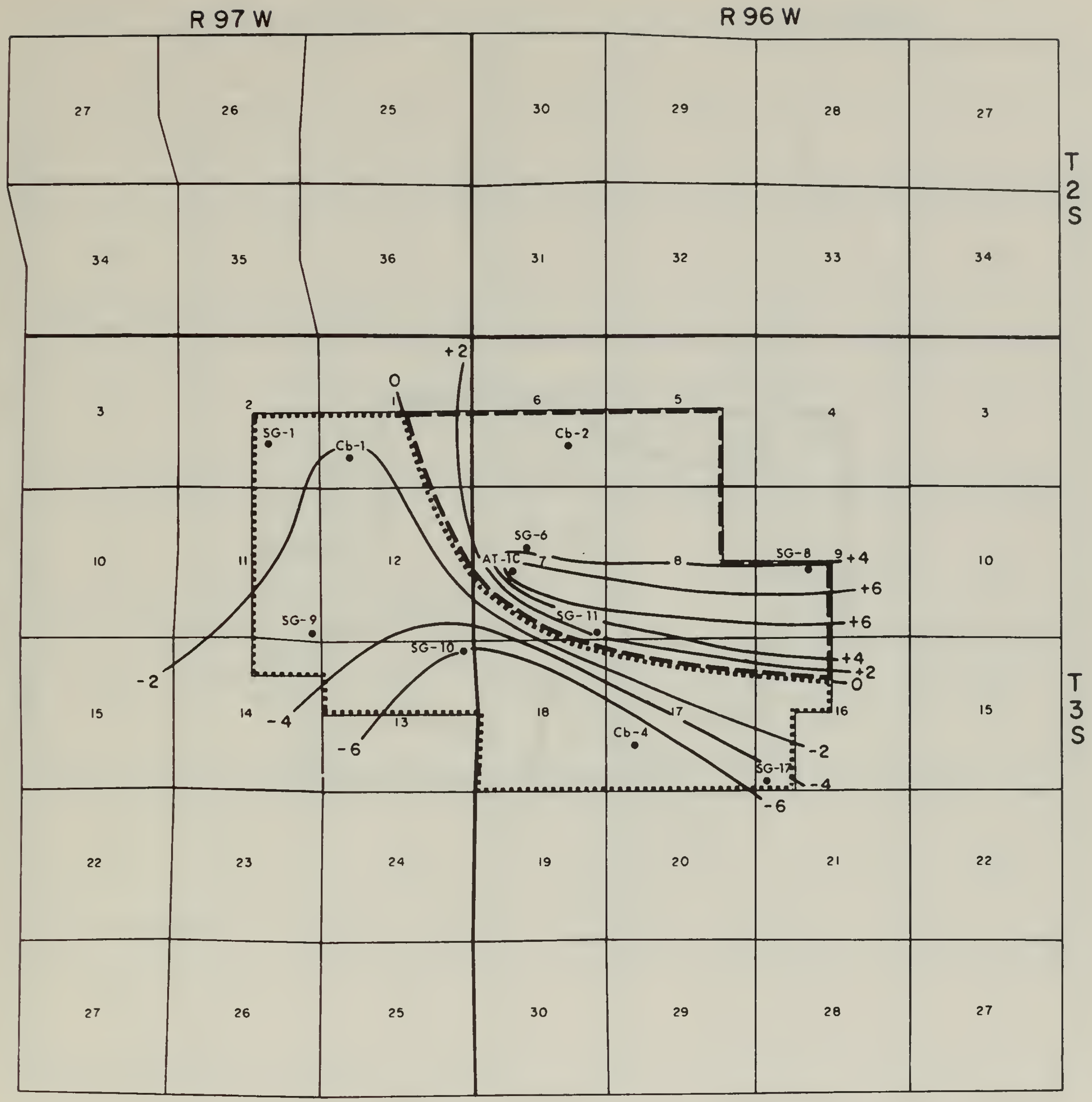
WELL LOCATION

	AT-1	AT-1C #1	AT-1C #2	AT-1C #3	A-1	A-2	A-3	A-5	A-6	A-7	A-8	A-9	A-10	A-11
1975 Dec.	6514.15	6515.43	6516.99	6547.05	6235.56	6269.92	6370.84	6325.70	6325.32	6347.77	6384.09	6491.87	6566.06	6448.95
1976 Jan.	6514.15	6517.85	6518.43	6548.82	6233.93	6269.63	6369.68	6325.50	6324.50	6347.32	6303.78	6491.65	6565.72	6449.35
Feb.	6518.72	6518.85	6519.36	6549.25	6233.83	6268.40	6369.09	6325.35	6324.13	6346.76	6384.65	6491.58	6563.05	6449.56
Mar.	6519.00	6517.25	6519.46	6549.45	6233.85	6268.46	6370.87	6325.35	6324.72	6347.67	6387.42	6491.90	6562.99	6450.10
Apr.	6519.12	6520.00	6520.50	6546.35	6233.85	6269.08	6369.06	6325.50	6324.57	6346.26	6385.76	6491.86	6562.98	6450.05
May	6518.99	6519.63	6520.29	6549.84	--	6268.95	6368.36	6325.75	6330.77	6344.26	6383.86	6491.36	6563.37	6450.17

	AT-12	SG-1 #1	SG-1 #2	SG-6 #1	SG-6 #2	SG-6 #3	SG-8*	SG-9 #1	SG-9 #2	SG-10*	SG-10A	SG-11* #1	SG-11 #2	SG-11 #3
1975 Dec.	6637.05	6363.12	6367.00	6491.87	6510.15	6559.33	--	6508.09	6516.13	6535.45	6573.17	--	6538.93	6549.80
1976 Jan.	6637.31	6366.98	6362.67	6493.06	6512.61	6556.54	6527.85	6507.97	6516.58	6535.55	6572.54	6499.02	6539.78	6549.18
Feb.	6637.60	6365.60	6360.79	6493.61	6513.30	6556.54	6528.00	6510.58	6520.17	6536.83	6576.66	6489.30	6537.82	6548.91
Mar.	6638.07	6365.65	6359.80	6493.59	6513.21	6556.13	6523.57	6510.72	6520.75	6537.50	6574.49	6489.25	6537.76	6548.80
Apr.	6638.93	6364.57	6360.32	6493.82	6514.12	6556.17	6522.04	6510.90	6520.22	6537.53	6577.75	6489.23	6537.72	6548.47
May	6639.50	6364.31	6364.27	6493.94	6514.19	6558.89	6528.39	6510.90	6520.62	6537.93	6577.96	6489.23	6537.56	6548.44

	SG-17* #1	SG-17 #2	SG-18A	SG-19	SG-21	Cb-1	Cb-2	Cb-3	Cb-4
1975 Dec.	6624.72	6639.40	6896.02	--	6703.83	6403.55	6408.85	6415.65	6625.76
1976 Jan.	6625.08	6639.81	6896.12	6379.03	6704.13	6404.57	6408.32	6412.15	6626.45
Feb.	6625.28	6639.75	6895.98	6379.30	6703.72	6403.83	6511.26	6410.35	6627.08
Mar.	6624.85	6639.68	6896.40	6380.10	6703.84	6404.03	6412.54	6415.15	6627.50
Apr.	6624.92	6639.72	6897.02	6379.84	6703.90	6403.81	6411.57	6415.35	6627.30
May	6628.48	6640.85	6896.56	6380.29	6703.64	6404.13	6413.20	6415.10	6626.95

*Recompleted



● Deep Wells

LOWER AQUIFER

▨ Water Level Fall

☐ Water Level Rise

Figure II A-2

WATER LEVEL CHANGE MAP
Aug-Nov, 1975

Fig. II A-

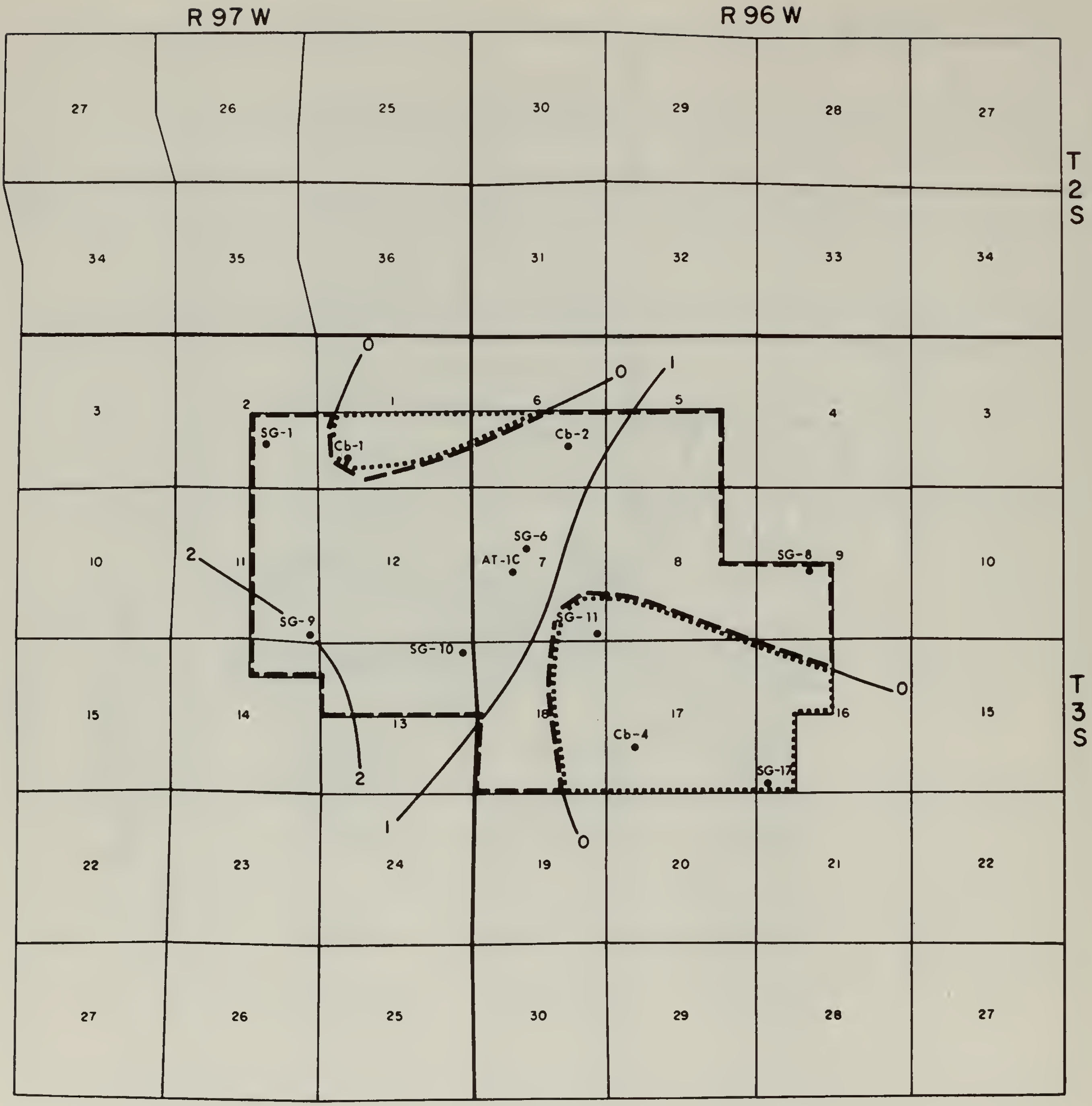
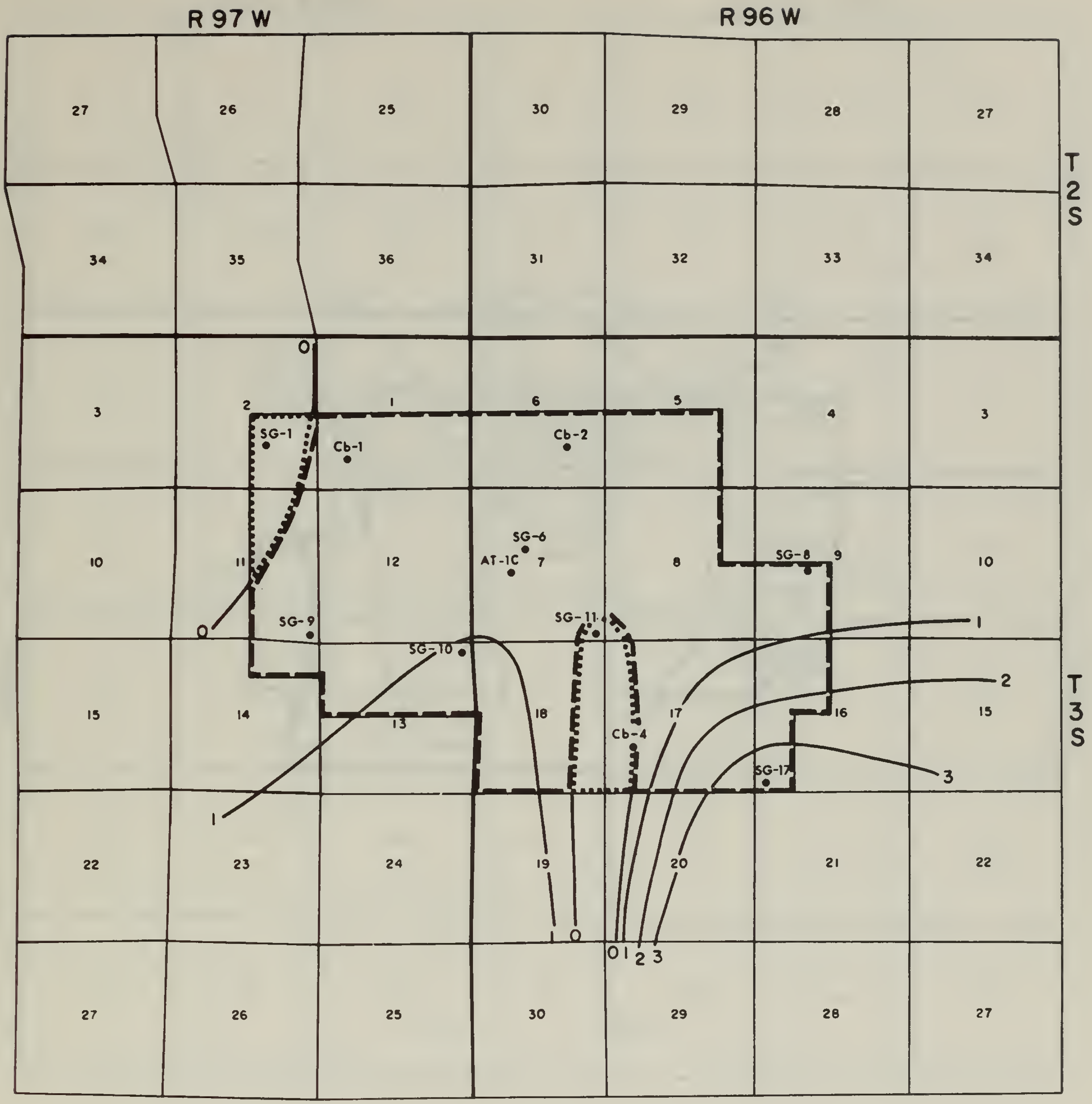


Figure II A- 3

WATER LEVEL CHANGE MAP
Nov, 1975-Feb, 1976

Fig. II A-



• Deep Wells

LOWER AQUIFER

▨ Water Level Fall

▭ Water Level Rise

Figure II A-4

WATER LEVEL CHANGE MAP
Feb, 1976 – May, 1976

Fig. II A-

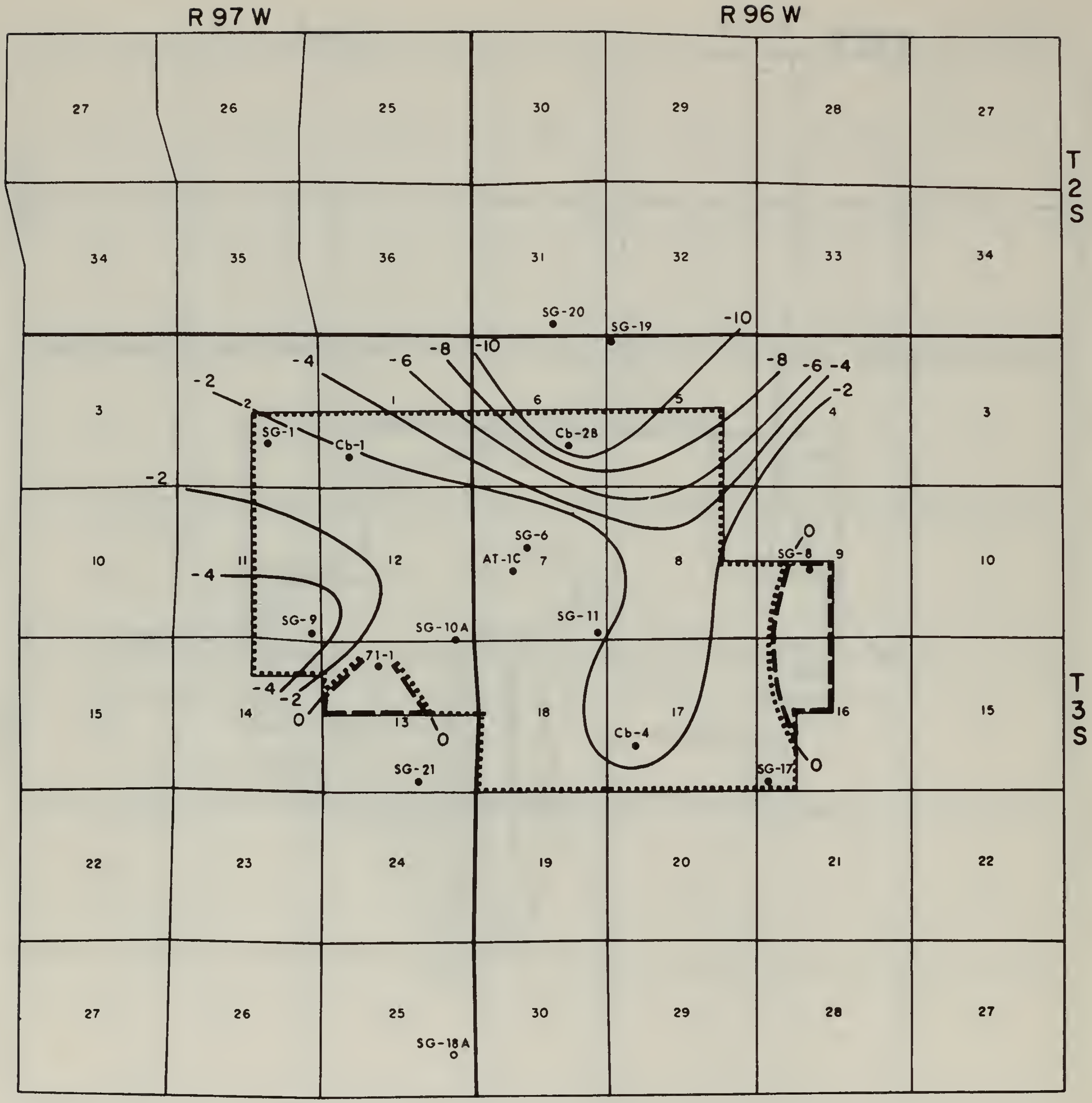


Figure II A- 5

WATER LEVEL CHANGE MAP
Aug - Nov, 1975

Fig. II A-

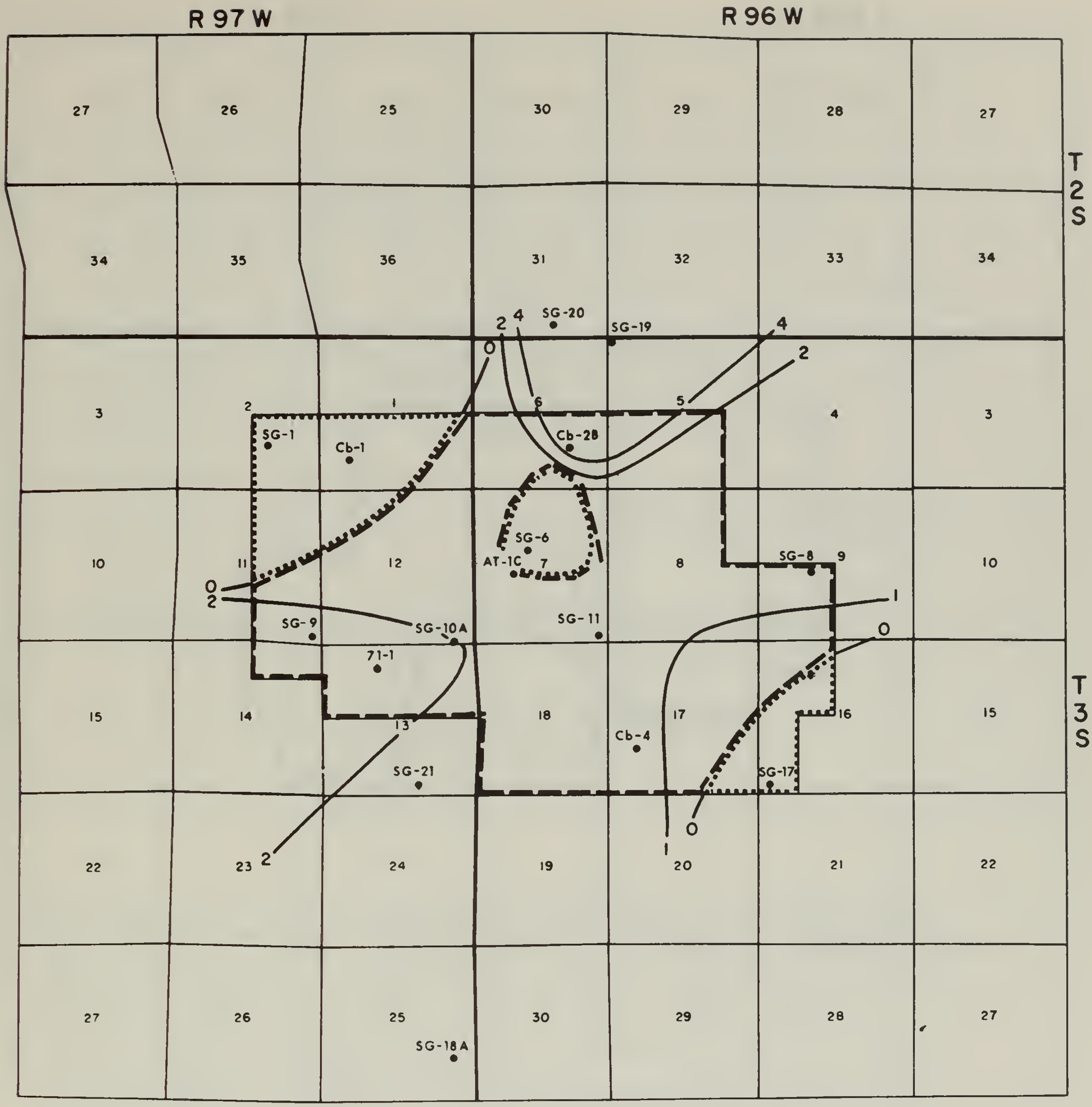
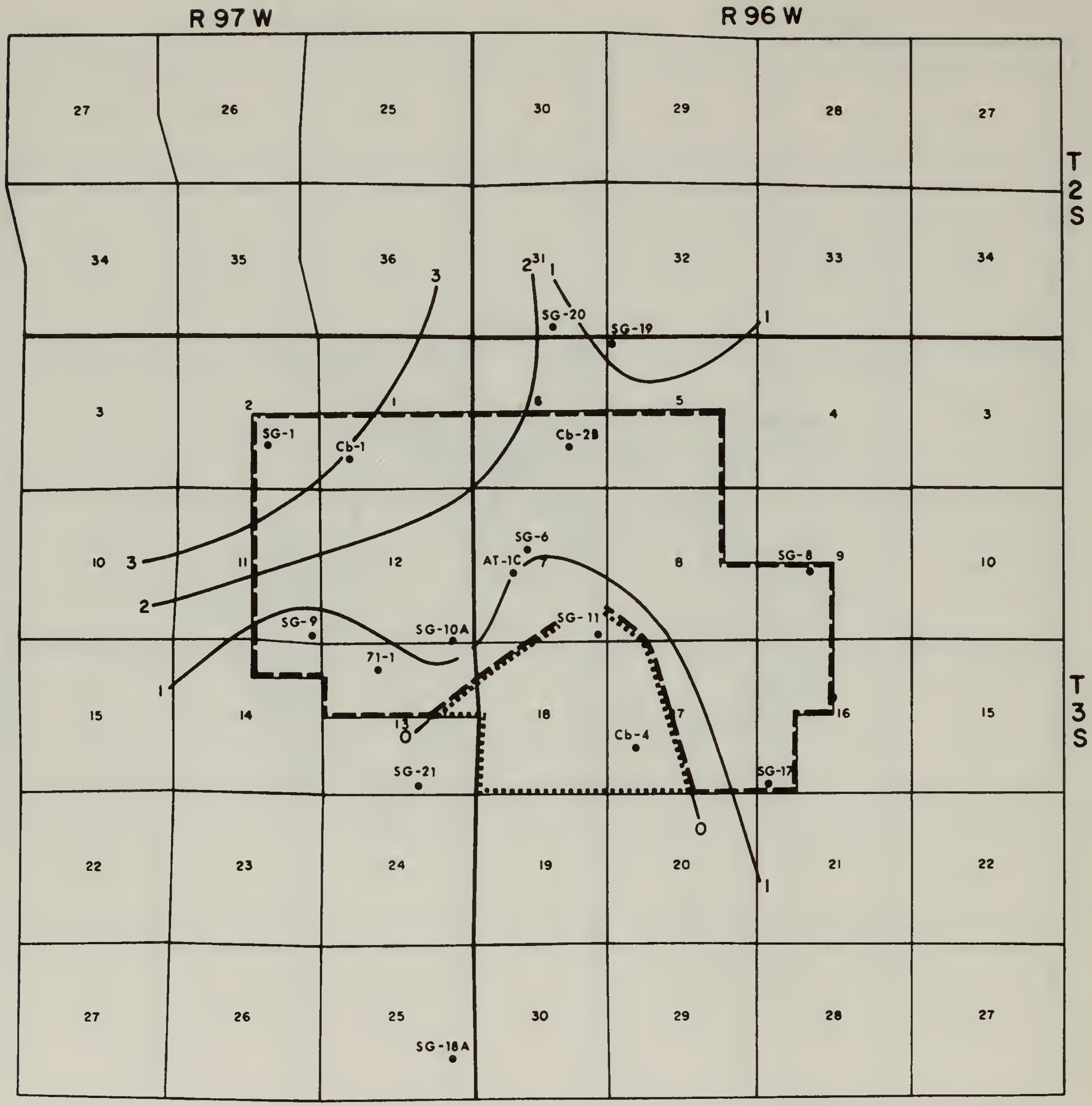


Figure II A-6

WATER LEVEL CHANGE MAP
Nov, 1975–Feb, 1976

Fig. II A-



- Deep Wells

UPPER AQUIFER

▨ Water Level Fall

▭ Water Level Rise

Figure II A-7

WATER LEVEL CHANGE MAP
Feb, 1976 – May, 1976

Fig. II A-

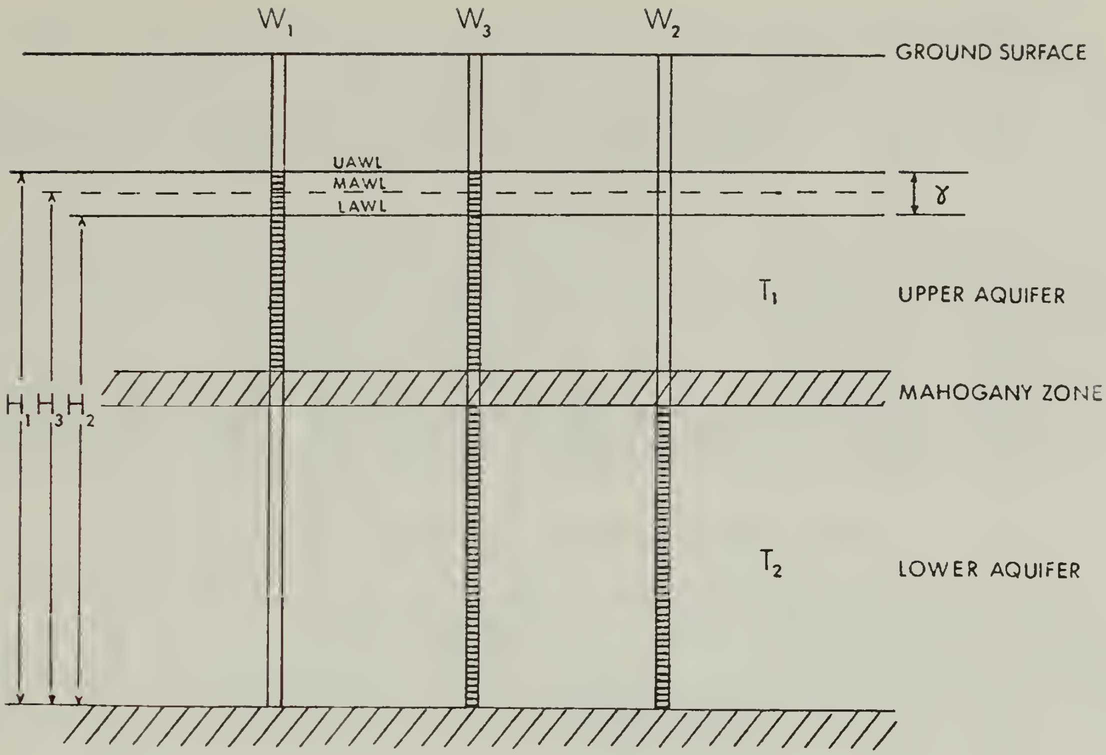


Figure II A-8 GENERALIZED CROSS SECTION
OF C-b TRACT AREA

For example, in the above figure assume that well W_1 is open only to the upper aquifer. The upper aquifer water level (UAWL) will be observed in this well at a height H_1 from the datum level. If well W_2 is open only to the lower aquifer, then it may be used to determine the lower aquifer water level (LAWL), given as height H_2 from the datum. A well such as W_3, open to both aquifers simultaneously, will exhibit an intermediate value, the multiple aquifer water level (MAWL), given by the height H_3. H_3 is given by $(H_1T_1+H_2T_2)/(T_1+T_2)$ where T_1 and T_2 are the transmissivities of the respective aquifers. As soon as well W_3 is completed, water will begin to flow through the well bore between the two aquifers and the level H_3 will be reached almost immediately. At horizontal distances from W_3 the water level in the upper aquifer would be falling with time and the water level in the lower aquifer would be rising. As time increases, the UAWL and LAWL will approach the MAWL. Observed water levels in the upper and lower aquifers will therefore be a function of time and radial position from any open well such as W_3. There are several such wells on and near Tract C-b as a result of activities occurring before the sale of the lease, as enumerated below. To estimate the amount of bias that the existing open core holes might introduce into water level observations, the differential equation governing water-level rate of change was solved and the amount of bias tabulated in Table II A-9. It was assumed that the average original difference, γ, between UAWL

Table II A-9

EFFECT OF OPEN (TO BOTH AQUIFERS) WELLS ON WATER LEVEL ELEVATIONS

Upper Aquifer
Fall in Feet

Radial Distance in Feet \ Time in Days	0	150	750	1500	7500
0	5.00	5.00	5.00	5.00	5.00
500	0	1.35	1.68	1.77	2.03
1000	0	0.99	1.13	1.45	1.71
2000	0	0.64	0.99	1.13	1.40
5000	0	0.23	0.55	0.69	1.01
10000	0	0.04	0.26	0.39	0.69

Lower Aquifer
Rise in Feet

Radial Distance In Feet \ Time in Days	0	150	750	1500	7500
0	20.0	20.0	20.0	20.0	20.0
500	0	5.38	6.70	7.06	8.10
1000	0	3.94	5.32	5.80	6.84
2000	0	2.54	3.96	4.50	5.60
5000	0	0.90	2.20	2.76	4.02
10000	0	0.15	1.04	1.54	2.78

and LAWL was 25 feet on Tract C-b. As can be seen in the table, water levels in wells near any open core holes could be affected significantly. Although the effects are not additive, an observation well within the radius of influence of more than one open core hole will exhibit even larger effects than those tabulated for a single well.

Open core holes on and in the vicinity of the Tract which could be causing water level changes include CB-3, TG-71-1, TG-71-2, TG-71-3, TG-2-1, and Federal 2b. Locations of these wells are shown in Figure II A-9. The consistent rise in water level in the lower aquifer could be attributed in part to the influence of these wells. The U. S. Geological Survey is currently planning a remedial action program to rework such open holes. Any detailed model to predict water levels based on water-level observations would have to consider the history of these wells and their influence on relative aquifer levels.

A Statistical Comparison of Water Quality Data

If there were free mixing because of hydraulic communication between two aquifer systems, the mean values of the water quality parameters for these communicating systems could be expected to be approximately the same. According to this hypothesis, the subsurface water quality data were used to test the existence of hydraulic continuity between the four major hydrologic units on Tract C-b, i.e., i) upper aquifer, ii) lower aquifer, iii) alluvial aquifer, and iv) springs. Out of 29 water quality parameters selected for use in the test, more than 22 parameters showed nonexistence of free mixing. This would indicate no hydraulic continuity between any of these four subsystems. While this statistical conclusion cannot be completely decisive in judging the degree of hydraulic continuity, it can be taken as corroborative evidence.

It is accepted that the Mahogany mining zone is a semipermeable aquifer with a vertical hydraulic conductivity of the order of 3×10^{-4} ft/day. D. K. Todd (1960) classifies this kind of aquifer as impervious. For all practical purposes, the Mahogany zone is obstructing free hydraulic communication between the aquifers below and above this zone. However, under large differential pressure across this zone, the flow through even an almost impervious layer might be substantial over a large area. The analysis reported here is an attempt to interpret the subsurface water quality data collected in the C-b Tract baseline monitoring program with the objective of identifying the interactions, if any, between the subsurface hydrologic systems. The result may partly answer the question of existence of hydraulic communications between aquifer systems under natural dynamic equilibrium conditions. It is logical to assume that if there is free mixing of waters because of hydraulic continuity between the four hydrologic units, then the water quality parameters of individual subsystems would indicate this. Based on this hypothesis, a statistical test was conducted for equality of the means of these water quality parameters. The test was based on the asymptotic distribution of likelihood ratio for samples from more than two populations. The test was applied to the equality of 29 water quality parameters for all eleven combinations of four hydrologic units, taking four units, three units, and two units at

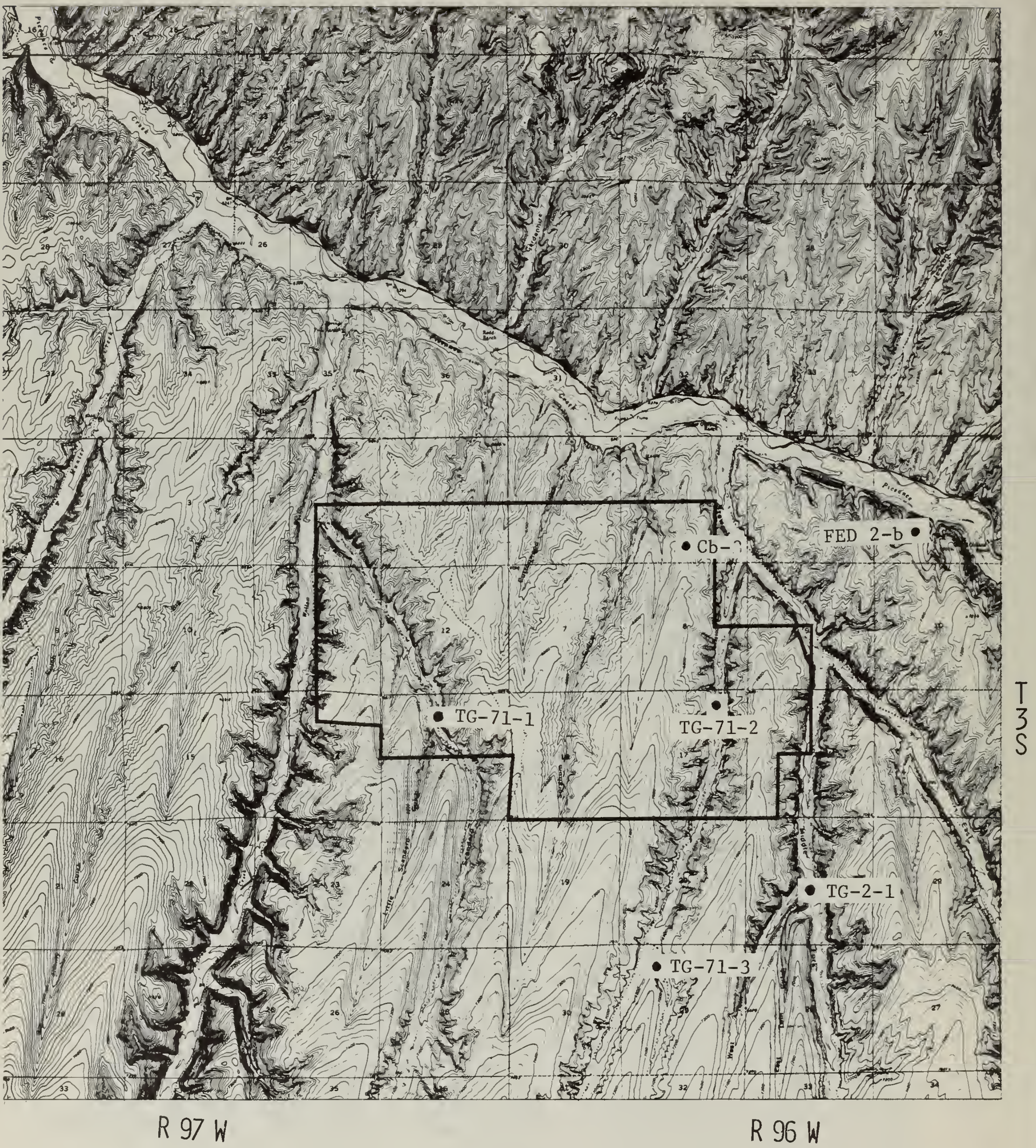


Figure II A-9
LOCATION OF PRE-LEASE OPEN CORE HOLES
ON AND NEAR TRACT C-b

a time. A test of size $\alpha=0.05$ (probability of rejecting the true hypothesis that the samples are derived from the same population) was assumed and the value of the statistic developed was compared to the quantile of the asymptotic distribution and the results are tabulated. A special computer program was developed for conducting the test.

Table II A-10 gives the result of the statistical inference on the interaction between the four hydrologic units under all possible eleven combinations. The '✓' indicates that the statistical analysis of the particular water quality parameter showed that the means of this parameter could have come from the same population (i.e., communication between aquifers) and an 'x' indicates the probability that they did not. A predominant number of water quality parameters support the hypothesis that there is no hydraulic communication between the four hydrologic units. This conclusion cannot be taken as decisive at this time. However, this testing procedure will be continued as further data become available to see whether the results are consistent.

Reference

D. K. Todd, Ground Water Hydrology, John Wiley & Sons, Inc., New York, 1960.

Table II A-10
STATISTICAL INFERENCE ON INTERACTION BETWEEN FOUR HYDROLOGIC UNITS

U-upper acquifer; L-lower aquifer; A-alluvial aquifer; S-springs

Combinations Water Quality Parameters	ULAS	ULA	ULS	UAS	LAS	UL	UA	US	LA	LS	AS
Ca	x	x	x	x	x	x	x	x	x	x	x
CO_3	x	x	x	x	x	x	x	x	x	x	x
Cl	x	x	x	x	x	x	x	x	x	x	x
Li	x	x	x	x	x	x	x	x	x	x	x
Mg	x	x	x	x	x	x	x	x	x	x	x
NO_3	x	x	x	x	x	x	x	x	x	x	x
PO_4	✓	✓	✓	✓	✓	✓	✓	x	✓	✓	✓
K	x	x	x	x	x	x	x	x	x	x	x
Na	x	x	x	x	x	x	x	x	x	x	x
SiO_2	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓
SO_4	x	x	x	x	x	x	x	x	x	x	x
NH_3	x	x	x	x	x	x	x	x	x	x	x
Al	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	✓
Ba	x	x	x	x	x	x	x	x	x	x	x
B	x	x	x	x	x	x	x	x	x	x	x
Co	x	x	x	x	✓	x	x	x	✓	✓	✓
F	x	x	x	x	x	x	x	✓	x	x	x
Pb	✓	✓	✓	✓	✓	✓	x	x	✓	✓	✓
Mn	x	x	x	x	x	x	x	x	x	x	x
Mo	✓	x	✓	✓	✓	x	x	✓	✓	✓	✓
Ti	x	x	✓	✓	x	x	x	✓	x	x	x
Cond.	x	x	x	x	x	x	x	x	x	x	x
pH	x	✓	x	✓	✓	x	✓	x	✓	x	✓
TDS	x	x	x	x	x	x	x	x	x	x	x
Palk	x	x	x	x	x	x	x	x	x	x	x
MOalk	x	x	x	x	x	x	x	x	x	x	x
Hard.	x	x	x	x	x	x	x	x	x	x	x
TOC	x	x	x	x	x	x	x	x	x	x	x
HCO_3	x	x	x	x	x	x	x	x	x	x	x
TOTAL "✓"s	5	5	6	7	6	4	4	5	7	5	7

✓ indicates that the means may be from same population
x indicates that the means are not from same population

II B AIR QUALITY

The current air quality/meteorology network is shown on Figure II B-1, and includes five air-quality trailers, the meteorological tower, two acoustic sounders, three ground-level mechanical weather stations, and an area-wide visibility site. Stations 020, 021, and 022 are located in the Piceance Creek Valley at Redd Ranch, Rock School, and the Gerald Oldland Ranch, respectively. Stations 023 and 024 are located on the Tract plateau. The sounders are co-located with Stations 021 and 023. The mechanical weather stations are located in the Piceance Valley in Section 9 (T2S, R97W) near Dudley Bluffs (Station 031), on the north-west corner of the Tract in Section 2 (T3S, R97W) near Scandard Gulch (Station 032), and near the southern edge of the Tract in Section 17 (T3S, R96W) near the West Fork of Stewart Gulch (Station 033). The visibility site is located off-Tract in the southwest quarter of the southwest quarter of Section 19 (T3S, R97W) along the Hunter Creek Road near Dry Gulch. The reader is referred to Tables II C-1 and II C-2 of Quarterly Data Report #5 for specific data measurements and sampling frequencies.

The air quality discussion is divided into paragraphs as follows: Air Quality and Surface Meterology, Low Altitude Meteorology, Upper Air Studies, Visibility, Noise, and Atmospheric Diffusion Studies.

II B-1 Air Quality and Surface Meteorology

Tables II B-1 through II B-5 summarize the maximum concentrations for the gases and particulates from December 1975 through February 1976. These concentrations, listed for 5-minute, 1-hour, 3-hour, 8-hour, and 24-hour maxima, correspond to the time intervals determined by State and Federal regulations. Table II B-6 presents the frequency distribution by concentration per station for particulates and shows the geometric mean for the three months. Tables II B-7 through II B-15 tabulate the monthly maximum sliding one-hour averages. In the case of hydrocarbons and the particulates, these maxima are for the 6:00 - 9:00 a.m. interval and 24-hour period, respectively. These are shown with the corresponding data, time of day, wind direction, and speed. Monthly averages follow on Table II B-16.

The lower detectable limits for the air-quality instruments are stated to be at 5 ppb with the exception of the ozone instrument which is given as 0.5 ppb. In practice the reliable lower detectable limit for the non-methane hydrocarbons is considerably above this; these represent some of the least reliable air quality data. The C-b Tract ambient air concentrations for all the gases, except for ozone and methane, are frequently near or below the measuring instrument's minimum detectable limit. Inherent measurement inaccuracies in most air quality instruments, particularly at or near their lower detection limits, make much of the air quality data interpretation a matter of judgement and experience.

(Text continued on Page 45)

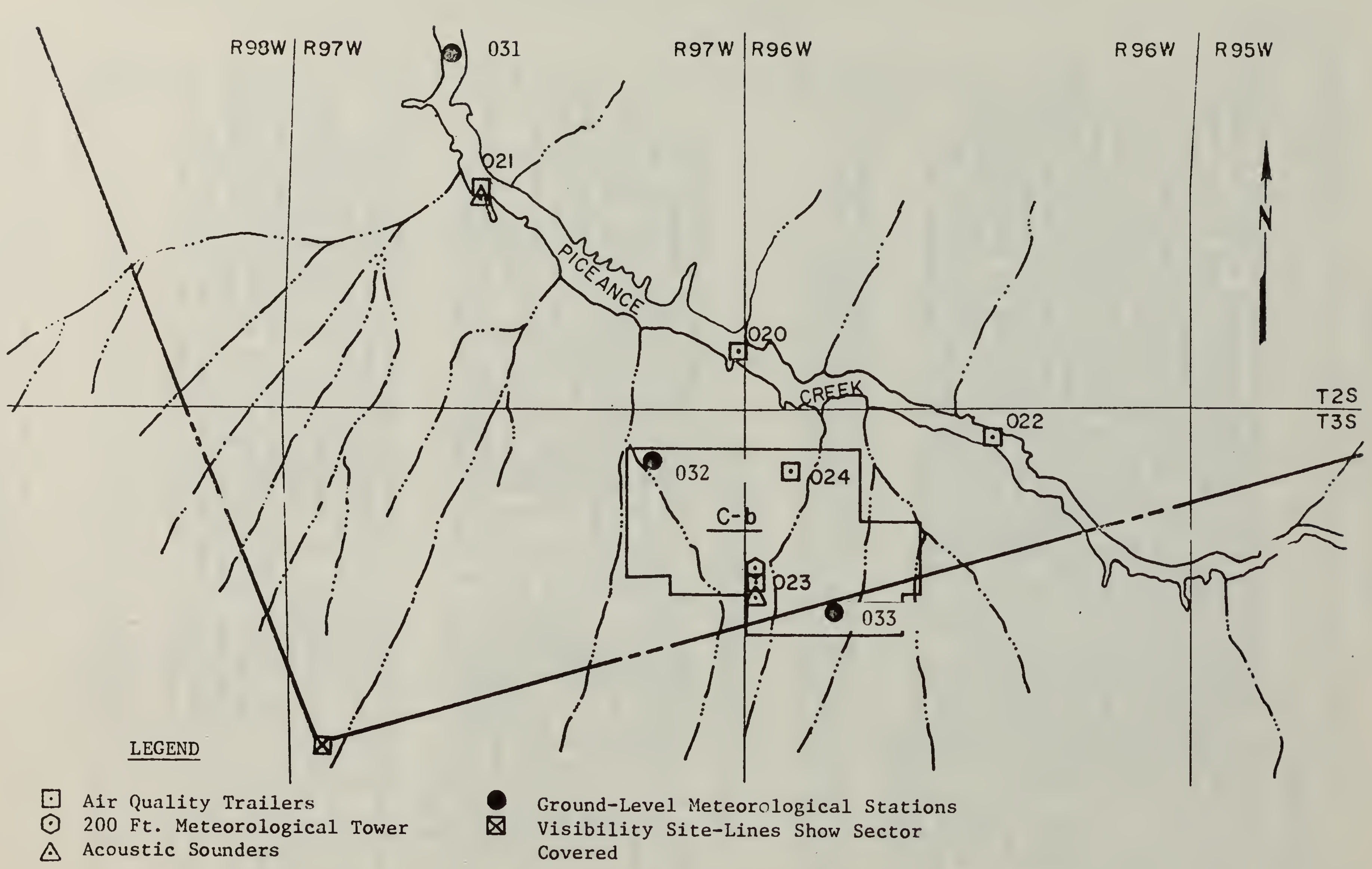


Figure II B-1 AIR QUALITY AND METEOROLOGICAL STATION LOCATIONS

TABLE II B-1. QUARTERLY SUMMARY (Dec. '75 - Feb. '76)
(Concentrations in micrograms per cubic meter)

TRAILER NO. 20

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO_2	0.0	0.3	2/17 12:00			2.2	2/17 11:55	3.5	2/17 14:25	41.7	2/17 14:55
H_2S	0.0							1.0	1/24 11:05	12.5	1/24 11:10
Particulates	3.1[1]	25.0	2/4								
Total Hydrocarbons	611.5					763.4	1/24 6:00			2332.1	1/4 12:50
CH_4	587.6					698.1	1/24 6:00			1422.3	12/4 13:30
Non-CH_4 Hydrocarbons	20.4					126.1	2/11 6:00			1161.1	2/8 8:55
O_3	32.9							102.6	12/13 14:45	107.5	12/13 15:30
NO_x	10.5							48.4	12/29 23:40	99.2	1/28 13:25
NO	7.4							37.8	12/30 3:00	71.1	1/23 23:10
CO	412.7			526.2	1/24 16:55			568.1	1/24 11:05	1711.8	1/22 0:20
NO_2	3.2							34.5	1/28 11:55	73.0	1/28 13:25

1 - Geometric Mean.

*Start of interval of occurrence.

TABLE II B-2. QUARTERLY SUMMARY (Dec. '75 - Feb. '76)
(concentrations in micrograms per cubic meter)

TRAILER NO. 21

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO_2	0.8	7.5	1/30 0:00			12.6	1/31 10:40	28.2	1/5 7:50	54.7	1/5 8:35
SO_2 [3]	0.7	13.1	1/4 13:00			29.1	1/5 10:00	51.4	1/5 11:10	55.4	1/5 11:45
Particulates	3.2 [1]	50.0	12/14								
Total Hydrocarbons											
CH_4											
Non-CH_4 Hydrocarbons											
O_3											
NO_x											
NO											
CO											

[1] - Geometric Mean.

*Start of time interval of occurrence.

[3] - January and February data.

TABLE II B-3. QUARTERLY SUMMARY (Dec. '75 - Feb. '76)
(concentrations in micrograms per cubic meter)

TRAILER NO. 22

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO_2	1.7	8.6	1/7 14:00			16.9	2/1 5:35	17.8	2/1 7:35	88.6	12/7 18:10
H_2S	0.0							2.0	12/14 10:35	9.7	12/4 10:10
Particulates	2.9[1]	30.0	12/4								
Total Hydrocarbons											
CH_4											
Non-CH_4 Hydrocarbons											
O_3											
NO_x											
NO											
CO											

[1] - Geometric Mean.

*Start of time interval of occurrence.

TABLE II B-4. QUARTERLY SUMMARY (Dec. '75 - Feb. '76)
(Concentrations in micrograms per cubic meter)

TRAILER NO. 23

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
H_2S[3]	0.2							4.9	1/2 8:20	27.4	1/12 11:30
H_2S	1.7							20.5	1/10 15:15	29.1	12/30 10:20
Particulates	2.5[1]	19.0	2/4								
Total Hydrocarbons	1170.5					2308.9	2/21 6:00			2546.3	12/19 11:45
CH_4	943.4					1533.8	2/21 6:00			2388.7	2/23 10:35
Non-CH_4 Hydrocarbons	235.8					929.6	2/26 6:00			1554.5	2/28 15:10
O_3	38.6							106.0	12/13 22:50	107.5	12/13 23:30
NO_x	4.1							59.1	12/9 11:35	67.4	12/9 12:00
NO	2.2							25.0	12/10 6:35	35.6	12/4 14:15
CO	1396.3			2729.5	1/11 14:55			3538.8	1/6 13:20	4411.6	1/6 14:00
NO_2	1.6							47.6	12/9 11:00	58.0	12/9 12:25

[1] - Geometric Mean.

[3] - Two month's data, Jan., Feb.

*Start of interval of occurrence.

TABLE II B-5. QUARTERLY SUMMARY (Dec. '75 - Feb. '76)
(Concentrations in micrograms per cubic meter)

TRAILER NO. 24

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO_2	0.4	6.9	12/7 11:00			9.6	12/14 9:45	10.0	12/14 2:30	78.1	12/4 14:10
H_2S	0.2							9.8	1/6 6:50	20.8	12/4 14:10
Particulates	2.9^1	60.0	1/25								
Total Hydrocarbons											
CH_4											
Non-CH_4 Hydrocarbons											
O_3											
NO_x											
NO											
CO											

1 - Geometric Mean.

*Start of time interval of occurrence.

TABLE II B- 6

PARTICULATE CONCENTRATION FREQUENCY DISTRIBUTION

December 1975 - February 1976

SITE	020	021	022	023	024
Concentration ug/m^3					
>260					
240-260					
220-240					
200-220					
180-200					
160-180					
140-160					
120-140					
100-120					
80-100					
60-80					
40-60		2			1
20-40	1	1	2		2
<20	90	84	87	89	85
TOTAL (No. of samples)	91	87	89	89	88
Geometric Mean (ug/m^3)	3.1	3.2	2.9	2.5	2.9

Table II B-7

1- HOUR MAXIMUM CONCENTRATIONS

SO_2

Constituent

By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)	11.9	.2	0.0	3.5	1.1	3.5						
	Date	11/15	12/12		2/17	3/14	4/4						
	Time (MST)	18:10	1:35		14:25	9:45	9:45						
	Wind Direction (Deg.)	113	99		296	175	210						
	Wind Speed (MPH)	4	3		10	8	6						
023	Value (ug/m^3)	2.0	19.1	51.4(1)	7.2(1)	23.4(1)	12.8						
	Date	11/18	12/13	1/5	2/6	3/13	4/28						
	Time (MST)	12:40	7:10	11:10	11:30	12:10	6:40						
	Wind Direction (Deg.)	241	139	129	311	128	266						
	Wind Speed (MPH)	12	5	14	3	7	2						
021	Value (ug/m^3)	11.7	5.2	28.2	10.4	54.6	18.2						
	Date	11/12	12/6	1/5	2/1	3/22	4/10						
	Time (MST)	11:20	23:40	7:50	0:00	14.20	3:30						
	Wind Direction (Deg.)	298	108	132	CALM	144	100						
	Wind Speed (MPH)	4	5	6		9	1						
022	Value (ug/m^3)	13.7	13.5	16.9	17.8	17.4	13.0						
	Date	11/1	12/7	1/8	2/1	3/14	4/16						
	Time (MST)	13:35	14:35	5:10	7:35	0:10	10:25						
	Wind Direction (Deg.)	266	125	101	115	CALM	186						
	Wind Speed (MPH)	6	2	5	10		3						
024	Value (ug/m^3)	22.1	10.0	5.9	3.0	4.6	4.3						
	Date	11/7	12/14	1/1	2/4	3/14	4/8						
	Time (MST)	3:20	2:30	14:20	12:30	4:30	9:55						
	Wind Direction (Deg.)	103	291	286	148	168	341						
	Wind Speed (MPH)	4	9	6	19	7	3						

(1) Side-by-side monitoring of H_2S in Trailer 023 and of SO_2 in Trailer 021 was initiated, as a data reliability check, for three months beginning 1 January, 1976. Therefore, no SO_2 data were taken at 023. The data from the second SO_2 analyser at 021 are reported in the row for 023 for January, February and March.

Table II B-8
1- HOUR MAXIMUM CONCENTRATIONS

H_2S

Constituent

		1975		1976									
Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)	2.0	.8	1.0	.2	5.0	30.9						
	Date	11/10	12/12	1/24	2/15	3/8	4/5						
	Time (MST)	9:25	2:05	11:05	8:55	10:15	15:55						
	Wind Direction (Deg.)	229	57	43	115	310	144						
	Wind Speed (MPH)	7	2	0	5	1	10						
023	Value (ug/m^3)	6.9	10.0	20.5	7.4	3.5	7.1						
	Date	11/29	12/6	1/10	2/11	3/5	4/26						
	Time (MST)	8:50	8:50	15:15	14:55	4:55	13:50						
	Wind Direction (Deg.)	140	57	7	202	CALM	213						
	Wind Speed (MPH)	2	3	3	12		15						
021	Value (ug/m^3)	4.6	2.8	4.4(1)	3.7(1)	5.5(1)**	5.1						
	Date	11/27	12/27	1/2	2/13*		4/18						
	Time (MST)	9:40	11:25	8:20	21:35-22:50		5:00						
	Wind Direction (Deg.)	126	248	100	195-179		300						
	Wind Speed (MPH)	7	9	1	1-2		2						
022	Value (ug/m^3)	1.4	2.0	0	.3	.3	7.1						
	Date	11/25	12/14		2/26	3/13	4/22						
	Time (MST)	14:05	10:35		9:55	11:55	10:55						
	Wind Direction (Deg.)	304	271		113	114	253						
	Wind Speed (MPH)	7	9		5	9	8						
024	Value (ug/m^3)	1.3	8.2	9.8	.8	2.4	7.7						
	Date	11/25	12/24	1/6	2/8	3/25	4/12						
	Time (MST)	13:00	10:55	6:50	9:45	17:35	14:45						
	Wind Direction (Deg.)	321	7	338	132	100	199						
	Wind Speed (MPH)	10	0	1	7	2	14						

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(1) Side-by-side monitoring of H_2S in Trailer 023 and of SO_2 in Trailer 021 was initiated, as a data reliability check, for three months beginning 1 January, 1976. Therefore, no H_2S data were taken at 021 and the data from the second H_2S analyzer at 023 are reported in the row for 021 for January, February, and March.

* Two maximums reported on same day.

** Maximums reported at 4 different times: 3/26 @ 22:15, 8mph. @ 146; 3/26 @ 23:20, 5mph. @ 118;
3/27 @ 0:25, 6mph. @ 136; 3/27 @ 2:40, 4mph. @ 101.

Particulate
Constituent

Table II B-9

24- HOUR MAXIMUM CONCENTRATIONS
1975-1976
Midnight - Midnight

		1975		1976									
Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)	20.0	11.0	19.0	25.0	25.0	79.0						
	Date	11/18	12/12	1/25	2/4	3/2	4/2						
	(1) 24-hr. ave. Wind Direction (Deg)	354	119	111	123	259	42						
	Max. 1-hr. ave. Wind Speed (MPH)	11	12	8	23	8	7						
	Wind Speed - 24-hr. ave. (MPH)	5	7	4	9	5	4						
023	Value (ug/m^3)	23.0	16.0	13.0	17.0	59.0	96						
	Date	11/18	12/12	1/24	2/4	3/2	4/2						
	(1) 24-hr. ave. Wind Direction	245	168	273	171	238	260						
	Max. 1-hr. ave. Wind Speed	19	24	14	27	10	11						
	Wind Speed - 24-hr. ave.	10	13	6	14	6	5						
021	Value (ug/m^3)	15.0	50.0	42.0	21.0	30.0	90						
	Date	11/10	12/14	1/4	2/4	3/2	4/2						
	(1) 24-hr. ave. Wind Direction	102	300	350	117	288	78						
	Max. 1-hr. ave. Wind Speed	13	14	11	20	9	10						
	Wind Speed - 24-hr. ave.	7	8	5	10	6	5						
022	Value (ug/m^3)	32.0	30.0	14.0	19.0	45.0	60						
	Date	11/25	12/4	1/25	2/4	3/2	4/2						
	(1) 24-hr. ave. Wind Direction	290	118	95	112	271	47						
	Max. 1-hr. ave. Wind Speed	12	12	10	21	8	13						
	Wind Speed - 24-hr. ave.	6	9	5	8	6	5						
024	Value (ug/m^3)	24.0	15.0	60.0	31.0	42.0	116						
	Date	11/27	12/12	1/25	2/29	3/2	4/2						
	(1) 24-hr. ave. Wind Direction	150	150	56	167	236	304						
	Max. 1-hr. ave. Wind Speed	10	19	7	12	12	13						
	Wind Speed - 24-hr. ave.	6	10	3	14	8	5						

(1) Vector Averages

Methane HC
Constituent

Table II B-10

3 - HOUR MAXIMUM CONCENTRATIONS
1975-1976
(6-9 a.m.)

		1975		1976									
Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)		678.9	698.1	675.5	NO	598.1						
	Date	NO	12/24	1/24	2/7		4/21						
	Time (MST)		---	---	---	DATA	100						
	Wind Direction (Deg.)	DATA	57	309	} CALM		2						
	Wind Speed (MPH)		1	2									
023	Value (ug/m^3)	1172.8	1098.2	1075.1	1533.8	1170.4	1123.0						
	Date	11/12	12/14	1/11	2/21	3/14	4/27						
	Time (MST)	---	---	---	---	---	---						
	Wind Direction (Deg.)	115	312	140	203	182	111						
	Wind Speed (MPH)	2	12	4	2	20	3						
021	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
022	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
024	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												

Non-Methane HC
Constituent

Table II B-11

3 - HOUR MAXIMUM CONCENTRATIONS
1975-1976
(6-9 a.m.)

		1975		1976									
Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)		116.7	65.3	126.1	NO	58.6						
	Date	NO	12/5	1/24	2/11		4/24						
	Time (MST)		---	---	---	DATA	---						
	Wind Direction (Deg.)	DATA	139	309	106		131						
	Wind Speed (MPH)		8	2	4		6						
023	Value (ug/m^3)	595.1	286.4	557.8	929.6	565.1	1992.6						
	Date	11/13	12/5	1/1	2/26	3/31	4/29						
	Time (MST)	---	---	---	---	---	---						
	Wind Direction (Deg.)	123	105	264	188	163	250						
	Wind Speed (MPH)	3	3	4	6	4	1						
021	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
022	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
024	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												

CO
Constituent

Table II B-12

1 - HOUR MAXIMUM CONCENTRATIONS

1975-1976

1975 1976

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)		501.4	568.1	NO	NO	NO						
	Date	NO	12/30	1/24									
	Time (MST)		0:35	11:05	DATA	DATA	DATA						
	Wind Direction (Deg.)	DATA	87	43									
	Wind Speed (MPH)		0	0									
023	Value (ug/m^3)	3157.6	2032.9	3538.8	3009.1	1861.8	1972.3						
	Date	11/26	12/11	1/6	2/27	3/22	4/5						
	Time (MST)	1:20	11:00	13:20	21:55	22:55	14:20						
	Wind Direction (Deg.)	89	221	302	123	125	188						
	Wind Speed (MPH)	0	8	11	2	5	1						
021	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
022	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
024	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												

NO
Constituent

Table II B-13

1 - HOUR MAXIMUM CONCENTRATIONS

1975-1976

		1975		1976									
Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)	27.8	37.8	37.8	30.9	44.3	64.1						
	Date	11/3	12/30	1/17	2/27	3/2	4/26						
	Time (MST)	5:15	3:00	21:25	3:55	7:30	1:50						
	Wind Direction (Deg.)	114	137	136	135	CALM	22						
	Wind Speed (MPH)	3	9	12	10		2						
023	Value (ug/m^3)	4.1	25.0	1.4	15.4	21.5	23.2						
	Date	11/29	12/10	1/21	24-25	3/4	4/20						
	Time (MST)	9:15	6:35	12:30	23:10 7:45	0:30	20:15						
	Wind Direction (Deg.)	205	101	331	131 189	261	202						
	Wind Speed (MPH)	2	3	2	2 5	2	8						
021	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
022	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
024	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												

NO_2

Constituent

Table II B-14
1 - HOUR MAXIMUM CONCENTRATIONS
1975-1976

		1975		1976									
Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)	29.2	23.1	34.5	19.7	24.5	51.0						
	Date	11/6	12/12	1/28	2.5	3/2	4/17						
	Time (MST)	7:45	10:40	11:55	9:00	6:25	20:10						
	Wind Direction (Deg.)	126	135	304	291	CALM	34						
	Wind Speed (MPH)	6	5	2	8		2						
023	Value (ug/m^3)	17.5	47.6	5.5	2.2	4.5	10.9						
	Date	11/18	12/9	1/5	2/21	3/6	4/20						
	Time (MST)	20:40	11:00	11:00	2:40	9:30	11:05						
	Wind Direction (Deg.)	308	13	189	208	332	263						
	Wind Speed (MPH)	13	2	11	1	2	4						
021	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
022	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
024	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												

O_3

Constituent

Table II B-15
1 - HOUR MAXIMUM CONCENTRATIONS

1975-1976

		1975		1976									
Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (ug/m^3)	72.3	102.6	51.0	51.1	63.2	131.1						
	Date	11/7	12/13	1/11	2/4	3/19	4/9						
	Time (MST)	12:25	14:45	11:55	6:20	5:00	16:00						
	Wind Direction (Deg.)	232	121	165	80	256	255						
	Wind Speed (MPH)	9	4	5	11	7	10						
023	Value (ug/m^3)	53.4	106.0	56.3	52.9	84.3	123.6						
	Date	11/6	12/13	1/5	2/10	3/19	4/26						
	Time (MST)	14:15	22:50	3:55	0:20	5:10	14:05						
	Wind Direction (Deg.)	230	316	149	214	226	213						
	Wind Speed (MPH)	13	12	3	22	19	15						
021	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
022	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												
024	Value (ug/m^3)												
	Date												
	Time (MST)												
	Wind Direction (Deg.)												
	Wind Speed (MPH)												

Table II B-16

MONTHLY AVERAGE AMBIENT AIR CONSTITUENT CONCENTRATIONS OF GASES AND PARTICULATES ($\mu g/m^3$)

1975-1976

Trailer	Item	1975		1976									
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	NO ($\mu g/m^3$)	2.6	3.4	12.5	5.7	(1)	(1)						
023		.0	2.5	0.0*	(1)	2.0	.4						
020	NO_2 ($\mu g/m^3$)	8.5	2.2	4.8	2.1	(1)	(1)						
023		.8	2.6	(1)	(1)	.1	0.3						
020	O_3 ($\mu g/m^3$)	30.9	32.7	35.7	30.7	40.2	66.5						
023		39.2	38.2	37.1	41.2	45.2	68.0						
020	Non-Methane H.C. ($\mu g/m^3$)	No Data	26.4	20.5	(1)	(1)	(1)						
023		303.8	151.3	171.2	389.7	388.7	818.3						
020	CH_4 ($\mu g/m^3$)	No Data	579.5	592.5	(1)	(1)	(1)						
023		920.6	909.6	862.5	1046.6	1046.6	1007.2						
020	CO ($\mu g/m^3$)	No Data	(1)	408.5	(1)	(1)	(1)						
023		1847.3	(1)	1787.3*	1161.8	1271.5	657.0						
020	SO_2 ($\mu g/m^3$)	.0	.0	.0	.0	.0	.0						
021		.9	.0	1.7	.2	.6	.8						
022		.1	1.4	1.9	1.7	1.4	1.0						
023		.0	.2	1.1(2)	.1(2)	2.6(2)	.5						
024		1.1	.8	.2	.1	.2	.3						
020	H_2S ($\mu g/m^3$)	.1	.0	.0	.0	.1	.3						
021		.1	.2	0.2(2)	.2(2)	.1(2)	.7						
022		.0	.1	.0	.0	.0	.6						
023		.4	.9	3.3	.9	.4	.3						
024		.0	.1	.4	.0	.0	.0						
020	Particulate ($\mu g/m^3$)	5.0	2.8	3.2	3.2	7.5	14.7						
021		4.3	3.7	3.4	2.7	6.9	14.0						
022		4.6	2.8	3.3	2.6	5.7	12.5						
023		3.9	2.3	2.8	2.4	5.5	9.8						
024		5.3	2.5	3.3	3.0	7.5	14.4						

(1) Few or no data collected because of instrument malfunction

(2) Side-byside monitoring of H_2S in Trailer 023 and of SO_2 in Trailer 021 was initiated as a data reliability check for three months beginning 1 January, 1976. Therefore, no SO_2 data were taken at 023 and no H_2S data were taken at 021. The data from the second SO_2 analyzer at 021 are reported in the row for 023 for January, February and March. Data from the second H_2S analyzer at 023 are reported in the row for 021 for January, February and March.

* 50% or Less Data

A three month study was conducted during January, February, and March in which two identical, side-by-side SO_2 analyzers were operated in Station 021 and two H_2S analyzers were operated in Station 023. In each station both analyzers were connected to the same air intake manifold and to the same hydrogen supply. The goal of the study was to evaluate the agreement between the analyzers, and thus obtain some indication of the significance of the readings which have been obtained so far in the monitoring program.

The instruments used for both SO_2 and H_2S monitoring are the flame photometric detector type (Meloy SA 185-2) with full scale range of 1,000 ppb (parts per billion). The manufacturer's specifications include the following:

minimum detection limit - 5 ppb (13 ug/m^3 for SO_2, for example)

maximum drift within a 24-hour period - ±1% full scale≅10 ppb (26 ug/m^3 SO_2)

accuracy - ±1% of full scale≅10 ppb (26 ug/m^3 SO_2)

During the three month test no high levels of SO_2 were recorded. The maximum level observed was 39 ug/m^3 on March 22, during a ten hour period when SO_2 concentrations were above the detection limit. The co-located SO_2 analyzer, however, was above minimum detection limit for 11 hours, and reached a peak of only 18 ug/m^3. These values are less than 2% of full scale and the agreement between the two is within the specified accuracy of the analyzers. Table II B-17 summarizes the results of the SO_2 test. Because of the very low levels observed it is difficult to draw definitive conclusions. No significant differences were observed between the two SO_2 analyzers, given the factory specification of ±1% drift per day and ±1% accuracy. As these specifications would suggest, the observed behavior of the SO_2 analyzers indicates that values in the range of 30 ug/m^3 probably contain a 100% uncertainty.

The peak H_2S levels during the three month test were even lower than the SO_2 levels. The two H_2S analyzers were in Station 023 on the plateau, and only during the month of January were concentrations above the detection limits observed. The results are summarized in Table II B-18. The highest concentraion observed was 25 ug/m^3 on January 5 during a two hour event. The co-located monitor did not indicate a signal above the detection limit during that time. As was the case with SO_2, the apparent H_2S events observed by one analyzer generally were not seen by the other. This could be attributed to the very low levels involved (∿1% of full scale), and the inherent drift and accuracy characteristics of the analyzers.

The February-through-April data for SO_2 show that the ambient concentrations were below the detection limit over 95 percent of the time. The maximum one-hour concentration occurred at Station 021 near Rock School on March 22 (Table II B-7), and reach 39 ug/m^3. Although this is higher than the levels observed during the same period last year, the difference is not considered to be significant. The monthly averages for SO_2 (Table II B-16) are not significantly different from the averages for the first

Table II B-17

RESULTS OF SO_2 ANALYZER TEST

		Monthly Averages	Percent of Hours Above Detection Limit	Maximum One Hour Difference Between Analyzers
Jan.	Analyzer 1	1 ug/m^3	0.8	28 ug/m^3
	Analyzer 2	2 ug/m^3	0.3	
Feb.	Analyzer 1	0 ug/m^3	0	0 ug/m^3
	Analyzer 2	0 ug/m^3	0	
Mar.	Analyzer 1	3 ug/m^3	5.3	26 ug/m^3
	Analyzer 2	2 ug/m^3	3.1	

Table II B-18

RESULTS OF H_2S ANALYZER TEST

		Monthly Averages	Percent of Hours Above Detection Limit	Maximum One Hour Difference Between Analyzers
Jan.	Analyzer 1	1.0 ug/m^3	0.8	25 ug/m^3
	Analyzer 2	3.0 ug/m^3		
Feb.	Analyzer 1	0 ug/m^3	0	0
	Analyzer 2	0 ug/m^3	0	0
Mar.	Analyzer 1	0 ug/m^3	0	0
	Analyzer 2	0 ug/m^3	0	0

year of monitoring. Because the majority of the recorded five-minute averages appear as zeros, these monthly averages are often computed to be less than the specified minimum detection limits. (This is also true for H_2S, NO, and NO_2). As was noted in the two previous summary reports, the SO_2 concentrations observed at Station 024 appear to coincide with a southerly wind direction. SO_2 was not monitored at Station 023 during February and March.

The H_2S concentrations for February through April were below the detection limits over 95 percent of the time. The maximum hourly average occurred at Station 020 on April 5, and reached 30.9 ug/m^3 during an H_2S event which lasted several hours. Neither the maximum hourly values nor the monthly averages (Table II B-16) are considered to be significantly different from those observed during the first year of monitoring. It should be noted that because of the special test discussed earlier, H_2S was not monitored at Station 021 during February and March.

The monthly average ozone concentrations (Table II B-16) increased significantly during March and April, but are lower than the levels observed during the same period last year. Since ozone is a secondary pollutant, i.e., a species formed from reactions of other pollutants, and since its rate of formation depends on many complex factors such as temperature, solar radiation, hydrocarbons, and nitrogen oxides, the reason for the decrease in ozone this year is not clear. This is particularly true since ozone may be derived from many sources, e.g., anthropogenic hydrocarbons and nitrogen oxides, natural hydrocarbons and nitrogen oxides, and from direct injection of ozone from the stratosphere.

Summary Report #6 discussed the results of an analysis of the first year of ozone data, and described results which indicate that long-range transport of urban air masses may have a significant impact on ozone levels at Tract C-b. A further analysis of the ozone data collected during the period November 1975 to April 1976, has recently been performed. This was presented in a paper entitled "Baseline Ozone Concentrations in Oil Shale Areas of the West", co-authored by David C. Jones and David C. Grossman (Radian Corporation). This paper was presented at the symposium on Fossil Fuel Technology sponsored by the University of Wyoming, June 17, 1976.

This paper examines the importance of stratospheric injection of ozone on air quality at Tract C-b. The basic approach was to screen the data for ozone events which were abnormal, e.g., nocturnal increases in the ozone concentration. Such an increase indicates that an ozone-containing air mass is moving into the area. This ozone could either be ozone which was formed through classic photochemical reactions at another location earlier in the day, or it could result from stratospheric injection of ozone.

Twelve nocturnal ozone events were observed, and three cases of these were selected for detailed meteorological studies to examine the possibility of stratospheric injection. These investigations consisted of: 1) analysis of the synoptic, or large-scale, meteorological situations during the period associated with the occurrence; 2) two-dimensional cross-sections of the atmospheric structure during the event, constructed from sounding data taken in the vicinity of Tract C-b by the National Weather Service; and 3) interpolation of surface air parcel trajectories obtained from National Weather Service. These investigations provided the paths taken by the air parcels reaching Tract C-b. From these trajectories it was an easy matter to determine if the air parcels passed over urban areas, which are sources of ozone precursors, before reaching the Tract.

The three cases chosen for study were:

1. December 13, 1975, beginning at 2200 MST
2. February 19, 1976, beginning at 2015 MST
3. April 22, 1976, beginning at 2300 MST

The data sequences on the night of December 13th showed that a strong cold front passed through the Tract C-b region at 2200 hours, accompanied by light snowfall. Thirty-five minutes later, the ozone concentration jumped from 22 parts per billion to 54 parts per billion and remained at this level for another 75 minutes before gradually decreasing. The five-minute averages of Table II B-19 illustrate this phenomenon. The meteorological analysis of this situation showed a strong upper-level low to the west of the region prior to frontal passage. As the strong cold front passed through the district, its associated surface low tracked very close to the Tract C-b region. Snowfall was general throughout the Utah - Colorado - Wyoming area.

An attempt was made to identify the possible source of the jump in ozone levels on this date. The surface air-parcel trajectory analysis, which traces the path of the ozone-bearing air during the previous 24 hours, showed that the air did not pass over any urban areas before reaching Tract C-b. However, a cross-sectional analysis of the frontal system as it was structured at 5 a.m. on the morning of December 14th indicated that an intrusion of ozone-bearing stratospheric air into the lowest levels of the atmosphere was possible. The frontal system nearly intersected the tropopause, which is the stable layer of air that separates the troposphere and the overlying stratosphere. The tropopause is normally lowest, about 25,000 feet above sea level, near strong cold fronts. Since air within and behind cold frontal systems descends, much of the ozone-rich stratospheric air that is entrained near the intersection of the frontal layer and the tropopause can subside to levels near the ground at some later time. This downward motion can be intensified by downdrafts associated with widespread snowfall in the region. An isentropic analysis, which was omitted from the cross-sectional analysis to simplify the discussion, revealed that the downward transport of air from the tropopause to near ground levels was indeed possible in this case. From all indications, then, most of the jump in ozone levels observed at the Tract C-b on the night of December 13, 1975, can probably be attributed to the injection of ozone-rich stratospheric air into the lower levels of the troposphere. This produced an increase in ozone concentration of about 65 ug/m^3.

Table II B-19

OZONE CONCENTRATIONS
December 13, 1975
at Station 023

Time (MST)	Ozone (PPB)	Wind Speed (Miles per Hour)	Wind Direction (Degrees)	Precipitation (Hundredths Inch.)
2120	16	4	152	0
2130	23	5	174	0
2140	11	2	209	0
2150	17	4	243	0
2155	13	6	268	0
2200	14	10	298	0
2205	18	9	307	0
2210	18	9	310	0
2215	20	10	317	0
2220	23	10	302	0
2225	23	10	298	0
2230	22	11	304	0
2235	54	9	301	0
2240	55	10	301	0
2245	54	9	294	1
2250	55	9	304	0
2255	54	9	308	0
2300	54	10	307	1
2310	54	8	299	1

The same general synoptic meteorological situation occurred in connection with the nocturnal ozone rise of February 19, 1976. A strong upper-level trough and surface cold frontal passage affected the region during the early evening, at about 2000 hours MST. The surface low pressure system moved very near Tract C-b. Again, surface air parcel trajectories indicate that the air traversed non-urban areas for the 24 hours preceding its arrival at Tract C-b, thus minimizing the possibility of an urban source of the ozone. Cross-sectonal analysis indicates that air originating at levels near 25,000 feet could have subsided to near-surface levels by the forced subsidence of air and snowfall-induced downdrafts. This February case is similar to that of the December case in that the cold frontal passage preceded the increase in ozone, and precipitation, in the form of snow, was beginning to fall at Tract C-b when the ozone levels showed the largest increase. Ozone levels only increased by 10 ug/m^3 during this event.

The final case study, that of April 22 and 23, 1976, was somewhat different from the previous cases. A cold frontal passage preceded the 12 ug/m^3 increase in ozone levels by about twenty minutes. However, the ambient air in the region prior to and following the frontal passage was very dry; there was no precipitation. In addition, the upper-level support of this frontal system was fairly weak, as was the surface portion of the front. Cross-sectional analyses of the system indicate that the downward transport of air in connection with this system was limited. Therefore, there is little support for the stratospheric injection of ozone. In addition, the air parcel trajectory analysis does not indicate that the air parcel passed over an urban area, thereby not acquiring ozone precursors before its arrival at Tract C-b. Therefore, the cause of this nocturnal rise in ozone is in doubt, but the rise nevertheless was associated with a cold frontal passage.

In all, twelve instances of nocturnal ozone increases were identified. Although only the three described above were subjected to detailed meteorological studies, frontal passages occurred in eight of the twelve cases. Based on these investigations, it appears that stratospheric injection of ozone may occassionally have a significant effect on ozone concentration at Tract C-b. In no observed case has it caused the ozone standard to be exceeded, however.

The February-through-April particulate data show an increasing trend which can be attributed to a decrease in snow cover and soil moisture. The observed levels are very similar to those observed a year ago. No particular difference was seen between the valley stations and the plateau stations (Table II B-16).

The NO and NO_2 levels were normally below the detection limits as evidenced by the low monthly averages (Table II B-16). The peak hourly average for NO_2 (51 ug/m^3) occurred on April 17 at Station 020. The wind was calm during this period, so this could have been a result of a build-up of automobile emissions in the valley. The peak NO hourly average occurred similtaneously, and reached 104 ug/m^3. As might be expected, the ozone level decreased to a very low level during this period. Assuming that traffic was the NO source, it was probably oxidation of NO by ozone which caused the NO_2 level to go as high as it did, and which caused the NO_2/NO ratio to be considerably higher than that emitted from vehicles.

The three hour maximum methane concentrations for February through April were not significantly different from the levels observed during the previous three months (Table II B-10). The methane levels on the plateau continued to be considerably greater than in the valley, for reasons which are not apparent. The monthly averages for non-methane hydrocarbons at Station 023 were slightly higher during this quarter than during the previous quarter (Table II B-16), although the difference does not appear significant. The peak three hour average, 6 to 9 a.m., occurred on April 29 at Station 023, and reached 1992 ug/m^3. This is by far the highest value observed so far this year; however, the cause is not known.

The monthly averages for carbon monoxide were considerably higher than a year ago during February and March, and about the same as a year ago during April. The April monthly average was only about one-half the February and March averages (Table II B-16), and the peak one-hour averages were not remarkably different from the last quarter. No explanation can be given at this time for the decrease in the April carbon monoxide levels.

Regarding surface meteorology, Tables II B-20 to II B-23 present a meteorological summary of temperature, relative humidity, and winds data for the five trailer stations (020 through 024) and three MRI mechanical weather stations (031 to 033) for February, March, and April, 1976. Wind speed, direction, and temperature at a seven-foot height are presented for the MRI weather stations. Using the logarithmic profile discussed in Summary Report #5, speeds are corrected to a 30-foot height by multiplying values obtained at a height of seven feet by a constant value of 1.421.

Hourly average temperatures for this quarterly reporting period ranged from an hourly maximum of 84° F at Station 032 on the plateau to an hourly minimum of -34° F at Station 021 in Piceance Valley. Temperature minima were up to 39° warmer (in March) on the plateau than in Piceance Valley; maxima were only 5° F warmer on the plateau than in the valley. A 61° F diurnal temperature range was experienced on March 6 at Station 021 where the drainage flows are strongest. It is of interest to note that Tract C-b stations in April achieved minimum daily temperatures that were equal to or lower than the "official low temperature for the nation" - Station 021 (lower on seven occasions), Station 020 (lower on two occasions), and Station 022 (lower on one occasion).

Monthly average temperatures for April were only 1° F to 2° F lower in the Piceance Creek Valley than on the plateau. This very small variation can be attributed to the lessening influence of the katabatic circulation cell on nocturnal temperatures in the valley as springtime develops. The April katabatic cell was much weaker than the March downslope circulation has been. This weakening in the katabatic cell from March to April was caused by three factors: 1) strong gradient winds during much of April; 2) increasingly shorter nocturnal periods for katabatic cell development; and 3) increased cloud cover during April (which inhibits katabatic cell development).

Table II B-20 METEOROLOGICAL SUMMARY: TEMPERATURE AND RELATIVE HUMIDITY 1975-1976

Trailer	Item	1975		1976										Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
020	Temperature, Hourly Max. (°F)	64	52	47	52	55	68							
021		64	50	47	52	55	68							
022		68	52	48	52	55	67							
023		63	50	47	48	51	63							
024		64	51	52	50	53	61*							
020	Temperature, Hourly Min. (°F)	-17	-14	-42	-21	-25	16							
021		-21	-27	-50	-18	-34	12							
022		-18	-12	-36	-9	-13	18							
023		4	6	- 6	6	5	22							
024		- 7	- 5	-26	0	-1	18*							
020	Temperature, Hourly Avg. (°F)	26	22	16	27	25	40							
021		24	19	12	26	24	40							
022		27	21	17	28	26	41							
023		32	28	24	31	29	42							
024		26	23	22	31	26	43*							
020	Rel. Hum., Hrly Max. (%)	100	98	99	98	99	100							
021		100	100	100	100	100	100							
022		100	100	100	100	100	100							
023		100	90	90	89	90	98							
024		100	98	100	100	100	100							
020	Rel. Hum., Hrly Min. (%)	16	32	28	21	20	14							
021		19	36	35	25	24	17							
022		22	35	33	27	25	20							
023		19	34	25	22	23	21							
024		22	32	29	26	30	21							
020	Rel. Hum., Hrly Avg. (%)	61	73	70	63	61	54							
021		70	81	78	70	67	59							
022		66	77	74	67	64	58							
023		53	62	62	57	56	53							
024		58	67	67	67	65	56							

* Less than 15 days' data.

Table II B-21 METEOROLOGICAL SUMMARY: TEMPERATURE
1975-1976

MRI STATION	ITEM	1975		1976										ANNUAL
		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	
031 032 033	Temperature Hourly Max. (°F)	66 69 67	52 56 52	48 44 53	54 (1) 55 (2)	59 68 49 (2)	73 84 65							
031 032 033	Temperature Hourly Min. (°F)	-10 - 9 - 3	-10 - 5 - 4	-23 -19 - 8	-14 (1) 2 (2)	-3 -8 3 (2)	-3 16 11							
031 032 033	Temperature Hourly Avg. (°F)	22 27 29	20 23 23	15 15 21	26 (1) 9 (2)	28 28 26 (2)	40 52 37							

(1) Missing data because of instrument malfunction. (2) Partial Data.

Table II B-22 METEOROLOGICAL SUMMARY: WIND SPEED & DIRECTION 1975-1976
(30 Foot Height)

Trailer	Item	1975		1976										Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
Tower 200'	Wind Speed, 5-Min. Max. (MPH) &	39	37	35	57	44	43							
	Associated Direction (Deg.)	308	200	198	217	187	248							
020	Wind Speed, Hourly Max. (MPH)	16	14	13	23	26	23							
021		20	17	14	20	22	25							
022		16	18	15	21	27	21							
023		33	25	27	32	28	25							
024		28	21	21	29	35	25							
020	& Associated Direction (Deg.)	147	104	140	304	292	154							
021		316	98	126	312	266	132							
022		114	281	116	286	279	112							
023		176	192	202	188	190	179							
024		188	183	187	208	275	178							
020	Wind Speed, Hourly Avg. (MPH)	5	5	5	6	5	5							
021		5	5	5	6	6	6							
022		6	6	6	6	6	5							
023		7	6	5	9	6	8							
024		6	5	4	8	8	8							
020	Wind Direction Hourly Avg. (Deg.)	117	112	110	132	127	118							
021		100	88	80	104	109	117							
022		119	110	106	112	109	106							
023		205	173	195	190	213	203							
024		144	116	121	146	155	157							

Table II B-23 METEOROLOGICAL SUMMARY: WIND SPEED AND DIRECTION*
1975-1976

MRI STATION	ITEM	1975 NOV	DEC	1976 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	ANNUAL
031 032 033	Wind Speed, Hourly Max. (MPH) &	28 17 35	28 19 28	28 15 28	29 (1) 29 (2)	30 25 38 (2)	38 28 28							
031 032 033	Wind Direction (Deg.) Associated w/Max. Reading	344 191 136	150 272 156	167 194 221	201 (1) 222 (2)	184 256 264 (2)	181 172 107							
031 032 033	Wind Speed, Hourly Ave. (MPH)	7 6 8	6 5 7	6 6 7	8 (1) 9 (2)	8 6 10 (2)	8 6 9							
031 032 033	Wind Direction, Hourly Ave. (Deg.)	182 170 184	211 148 163	206 157 190	204 (1) 201 (2)	215 174 195 (2)	205 169 196							

* Speed @ 30'; Direction @ 7'

(1) Missing data because of instrument malfunction. (2) Partial Data.

Hourly average relative humidity for the quarter has ranged from a minimum of 14 percent to a maximum of 100 percent. Hourly averages range from 53 to 81 percent over this time period.

Five-minute maximum wind speeds have reached 57 mph in this reporting period. Hourly maxima have reached 38 pmh on the plateau and in Piceance Valley. Hourly average (arithmetic) speeds at all stations were in the four to ten mph range; monthly vector averages ranged from 0.9 to 6.0 mph. Typical monthly wind roses on the plateau and in the valley are presented in Figures II B-2 and II B-3 for Stations 023 and 021 respectively. Associated prevailing directions continue to be from the south-southwest on the plateau and from the east to east-southeast (down-valley) along Piceance Creek with the west-northwest (up-valley) direction occurring to a lesser extent.

II B-2 Low Altitude Meteorology

The quarterly wind rose at the 100-foot level on the meteorological tower (Figure II B-4) indicates that the prevailing wind direction is from the south-southwest for the December-through-January quarter (as reported in Radian's latest quarterly report), which is similar to both the previous quarter and to the annual rose for the first year of baseline as presented in the Annual Summary and Trends Report.

Estimations of hourly average values of Pasquill-Gifford atmospheric stability categories made from the temperature difference data on the meteorological tower have been revised to include the effects of wind speed. Categories associated with ranges of dT/dz (i.e., slope of the temperature-height curve) are given in the second column of Table II B-24. Table II B-25 presents the technique for obtaining wind speed "adjustments" to these stability categories utilizing wind speed at 30 feet. Monthly stability class frequencies for both years of baseline are given on Table II B-24. Hourly average stability classes by month for both years of baseline are presented on Table II B-26 as obtained from both the tower and the pyranometer. The tower wind speed adjustments now bring the tower data into much closer agreement with the pyranometer. The selective stippled regions on Table II B-26 indicate unstable regions occurring in the middle of the day and the stable regions occurring in the evening and early morning; whereas the clear region depicts neutral stability. Statistically speaking, D stability was predominant in the first year of baseline; thus far in the second year, D has predominated for four months, A for one month, and E for one month.

II B-3 Upper Air Studies

As an extension of the above atmospheric stability discussion, Table II B-27 presents the average stability estimates at 600-foot and 1000-foot elevations for the previous four quarters of aircraft data, as now adjusted for wind speeds; hourly values are presented in the data report. Wind speeds were obtained from pibal releases on the same dates as the aircraft flights. Elevations of 600 and 1000-feet are considered "representative" of effective stack heights for diffusion modeling purposes.

Figure II B-2 STATION 023 30' ELEVATION WIND ROSES ('75-'76)

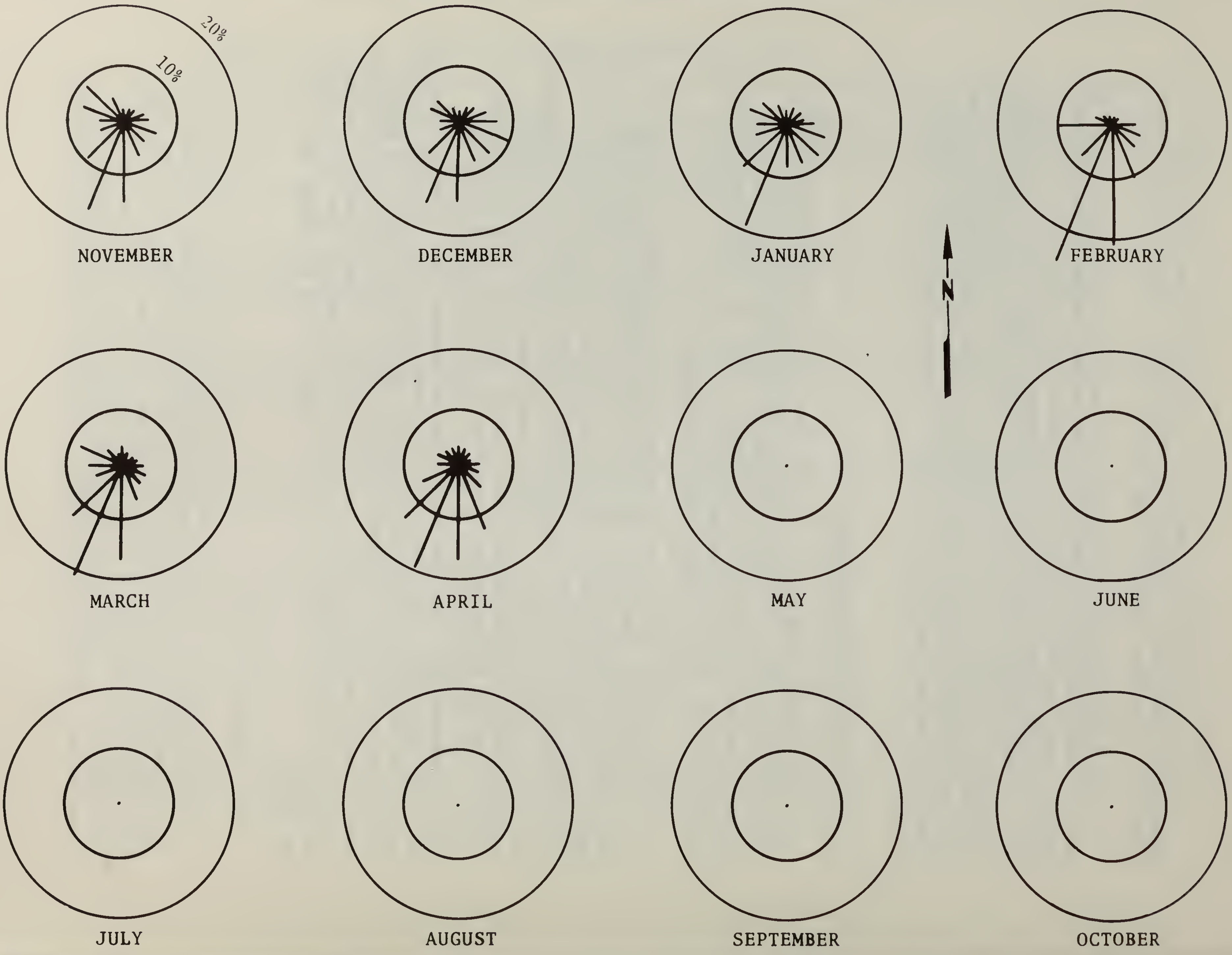

Figure II B-3 STATION 021 30' ELEVATION WIND ROSES ('75-'76)

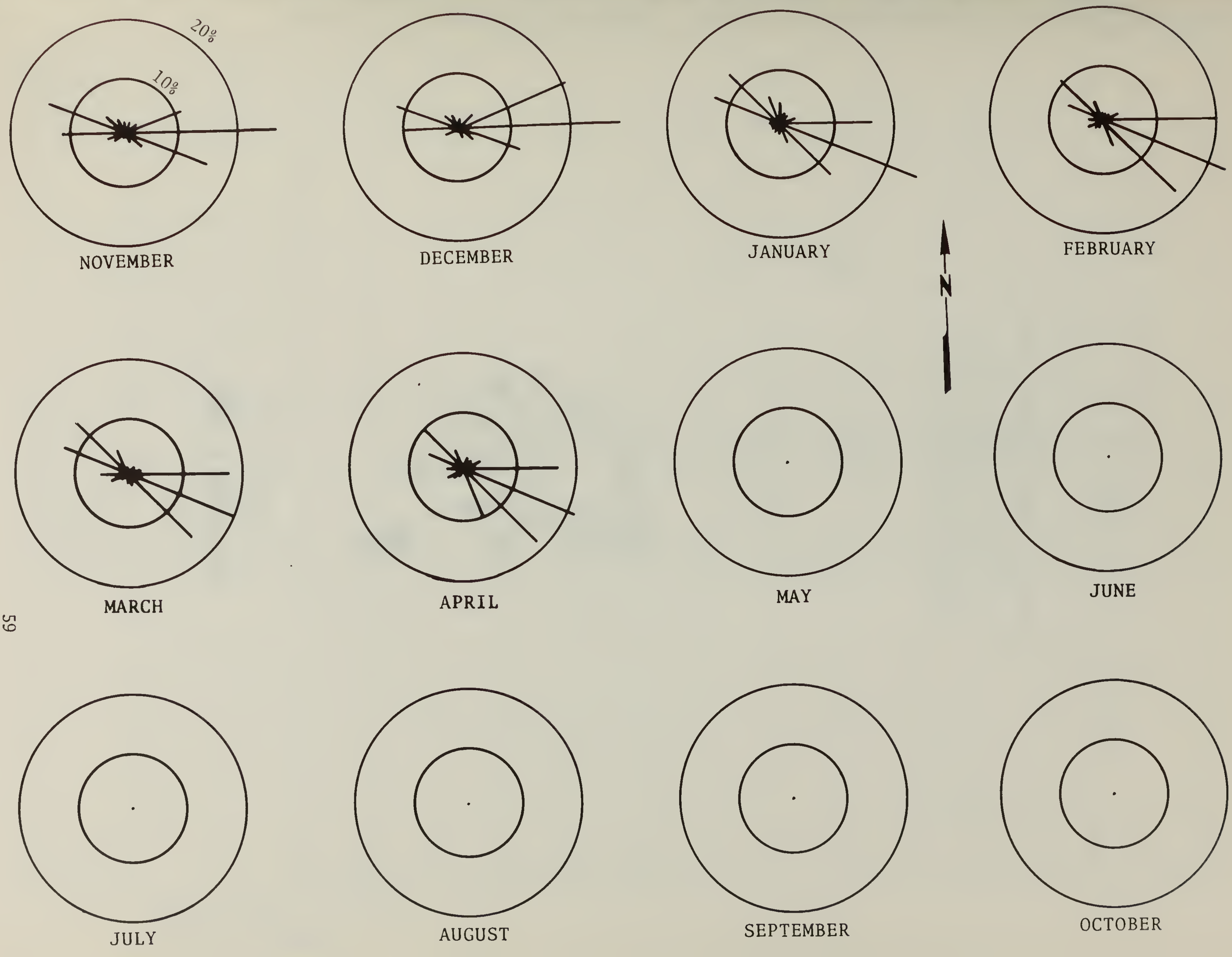

Figure II B- 4

QUARTERLY WIND ROSE-100' LEVEL
DEC. '75 - FEB. '76

TOTAL % OF CALMS DISTRIBUTED (0.91%)
TOTAL NO. OF 5-MIN. SAMPLES - 22649

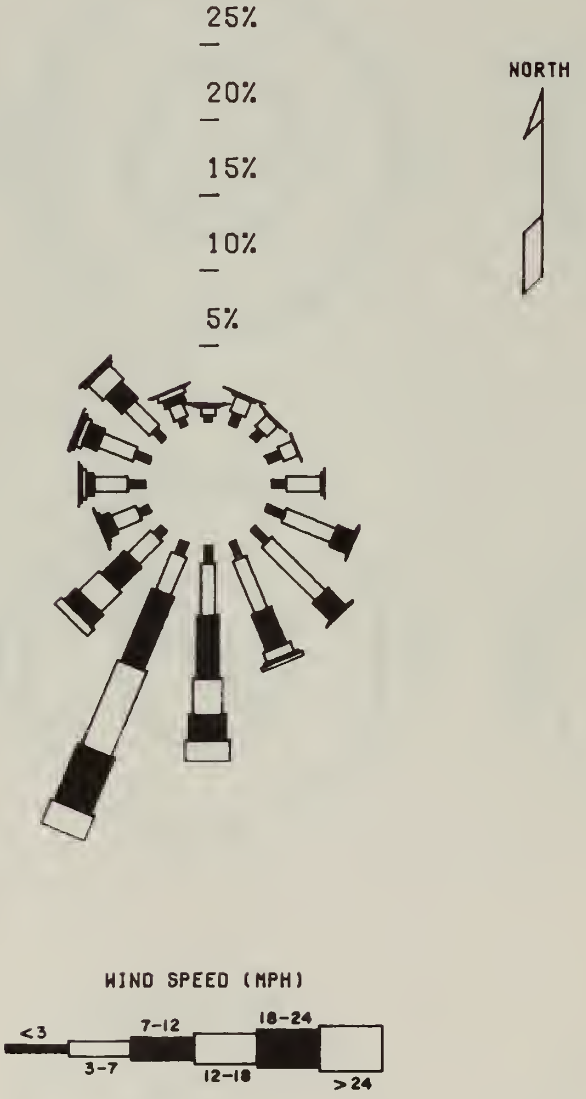

Table II B- 24 METEOROLOGICAL SUMMARY: STABILITY CLASS FREQUENCIES (%) Source: Met. Tower(1) (30' to 200')

Pasquill-Gifford Stability Class	dT/dz Range for this Stability Class (^oC/100m)	1974		1975										Annual
		Nov.(3)	Dec.(3)	Jan.	Feb.	Mar.	Apr.	May	June	July(2)	Aug.	Sept.	Oct.	
A	<-1.9			8.3	1.0	1.1	12.0	7.4	8.6	0.0	2.4	5.8	8.1	5.5
B	-1.9 to -1.7			5.5	4.4	10.3	23.5	30.6	25.6	85.7	19.3	23.4	20.6	24.9
C	-1.7 to -1.5			4.1	2.4	16.3	6.9	9.3	6.9	14.3	6.1	5.0	5.7	7.7
D	-1.5 to -0.5			33.0	43.4	60.9	36.3	30.0	27.0	0.0	25.8	13.4	28.3	29.8
E	-0.5 to +1.5			33.3	36.8	11.4	18.1	12.1	18.0	0.0	17.3	24.4	18.6	19.0
F	>1.5			15.8	12.0	0.0	3.2	10.6	13.9	0.0	29.1	28.0	18.7	13.1
Total				100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Pasquill-Gifford Stability Class	dT/dz Range for this Stability Class (^oC/100m)	1975		1976										Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
A	<-1.9	15.6	18.8	24.9	13.8	19.4	9.5							
B	-1.9 to -1.7	19.7	20.7	21.3	22.1	27.0	21.7							
C	-1.7 to -1.5	6.9	7.4	5.6	7.7	7.9	9.7							
D	-1.5 to -0.5	23.7	21.5	16.6	35.7	28.7	35.2							
E	-0.5 to +1.5	22.9	23.5	21.0	13.8	15.6	17.0							
F	>1.5	11.2	8.1	10.6	6.9	1.4	6.9							
Total		100.0	100.0	100.0	100.0	100.0	100.0							

(1) Adjusted for wind speed
(2) Partial Data
(3) Data are suspect

TABLE II B-25 WIND SPEED ADJUSTMENTS* TO PASQUILL - GIFFORD STABILITY CLASSES OBTAINED FROM METEROLOGICAL TOWER ΔT DATA**

STABILITY FROM TOWER ΔT (200' to 30')	WIND SPEED (WS) (MPH)	"ADJUSTED STABILITY"
A	$4.47 \leq WS < 11.18$	B
	$11.18 \leq WS \leq 13.42$	C
	$WS > 13.42$	D
B	$11.18 \leq WS \leq 13.42$	C
	$WS > 13.42$	D
C	$WS > 13.42$	D
D	ALL SPEEDS	D
E	$WS > 11.18$	D
F	$6.71 \leq WS \leq 11.18$	E
	$WS > 11.18$	D

* Source: EPA

** Use 30' on tower for wind speed reference.

Table II B-26 AVERAGE HOURLY STABILITY CLASSES

SOURCE: TEMPERATURE DIFFERENCES BETWEEN 200 FT AND 30 FT. ON THE MET TOWER
(Adjusted for Wind Speed)

Month	Hour																								Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Nov.*																									
Dec.*																									
Jan.75	D	D	D	D	D	D	D	D	E	E	E	E	D	D	D	D	D	D	D	E	D	D	D	D	D
Feb.	E	E	E	E	E	E	E	E	E	D	D	C	D	C	C	D	D	E	E	E	E	E	E	E	E
Mar.	D	D	D	D	D	D	D	D	C	C	C	C	C	C	D	D	C	C	D	D	D	D	D	D	D
Apr.	D	D	D	D	D	D	D	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	C
May	D	D	D	D	D	D	D	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	C
June	E	E	E	E	E	E	D	B	B	B	B	C	C	B	C	C	C	C	C	C	D	D	E	E	D
July	-	-	-	-MISSING	DATA-	-	-	-	-	-	-	B	B	B	B	B	B	C	-	-	-	-	-	-	B
Aug.	F	F	F	F	F	E	E	E	C	B	C	C	C	C	C	C	C	C	D	E	E	F	E	E	D
Sept.	F	E	E	F	F	F	F	E	B	B	B	B	B	C	B	B	C	B	E	E	E	F	F	F	D
Oct.	E	E	E	E	E	E	E	E	C	B	B	C	B	C	C	C	B	C	D	D	E	E	E	E	D
Nov.	D	D	D	D	D	D	D	D	C	B	B	B	C	B	B	B	B	C	D	D	D	D	D	D	D
Dec.	D	D	D	D	D	D	D	D	C	C	B	B	B	B	B	B	B	C	C	C	D	D	D	D	C
Jan.76	D	D	D	D	D	D	D	D	D	C	B	B	B	B	B	B	B	B	C	C	D	D	D	D	D
Feb.	D	D	D	D	D	D	D	D	C	C	C	C	C	C	C	C	B	B	C	D	D	D	D	D	C
Mar.	D	D	D	D	D	D	D	C	C	C	B	B	C	C	C	B	C	C	B	C	C	C	C	C	C
Apr.	D	D	D	D	D	D	D	B	F	C	C	C	C	C	D	C	C	C	C	D	D	D	D	D	C
May																									
June																									
July																									
Aug.																									
Sept.																									
Oct.																									

SOURCE: PYRANOMETER (DAYLIGHT ONLY)

Month		Hour																
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
Nov.																		
Dec.																		
Jan.'75						C	C	C	C	C	C	C						
Feb.						C	C	C	C	C	C	C						
Mar.						C	D	D	D	D	D	D						
Apr.						C	C	C	C	D	D	D						
May			C	C	C	C	C	C	C	C	D	D	D	D	D			
June			C	C	C	C	C	C	C	D	D	D	D	D	D			
July			C	C	C	B	B	B	C	C	C	C	C	C	D			
Aug.			C	C	C	C	C	C	C	C	C	D	D	D	D			
Sept.			C	C	C	C	C	C	C	C	C	C	C	D	D			
Oct.			C	C	C	C	C	C	C	C	C	C	D	D				
Nov.				C	C	C	C	C	C	C	C	D	D					
Dec.				C	C	C	C	C	C	C	C	D	D					
Jan.'76				C	C	C	C	C	C	C	C	D	D					
Feb.				C	C	C	C	C	C	C	C	C	D	D				
Mar.			C	C	C	C	C	C	C	C	C	C	D	D	D			
Apr.		C	C	C	C	C	C	C	C	C	C	D	D	D	D			
May																		
June																		
July																		
Aug.																		
Sept.																		
Oct.																		

KEY:

▧ Unstable Cases

D Neutral

☐ Stable

* Data are suspect

Table II B-27 C-b SHALE OIL PROJECT
STABILITY CLASS COMPARISON

	Hour 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
FALL					-(1)			-			-						-								Tower (average based on inclusive dates of aircraft data)
WINTER					E			E			D						D								
SPRING					E			B			C						C								
SUMMER					-(2)			-			-						-								
FALL					E			E			D						D								600' aircraft data
WINTER					D			D			D						D								
SPRING					E			D			D						D								
SUMMER					D			D			D						D								
FALL					D			D			D						D								1000' aircraft data
WINTER					D			D			D						D								
SPRING					D			D			D						D								
SUMMER					E			D			D						D								

(1) Tower data questionable (2) Tower data incomplete

Span of Aircraft Flights

FALL	(10/1/74 - 10/15/74)
WINTER	(1/20/75 - 2/9/75)
SPRING	(4/14/75 - 5/1/75)
SUMMER	(7/12/75 - 7/26/75)

Table II B-28 compares typical tower and pyranometer results with aircraft for the spring quarter (April 1975 aircraft flights). For the April example, only the tower indicated both A and F stability; the aircraft yielded all D's and E's; for the 11:00 a.m. MST flight time, the tower averaged C stability as did the pyranometer, whereas the aircraft averaged D. Thus from aircraft data at a 1000-foot height the "adjusted" stability indicated on all flights for all quarters was never anything other than D or E; only one C and one F were obtained at 600 feet. That portion of Figure II B-8 from Summary Report #6 depicting mean altitude of the top of the inversion layer from sounder data for which the probability of an inversion is greater than 0.5 (i.e. that portion for which an inversion is present on an "expected" basis) is presented here as Figure II B-5. This corroborates the fact that, on an expectation basis, F stability is not to be expected from aircraft data, except during summer, and then only if stability slopes are estimated below 1000-foot altitude. This is because inversion tops exceed 1000-feet only during the summer and only then for the 5:00 a.m. flights; no inversions exist on an expectation basis at other flight times. Restated, the tower should indicate a higher percentage of F stability than does the aircraft (at 600 feet and 1000 feet).

Inversion characteristics are reported from acoustic sounders at Stations 021 and 023. Table II B-29 lists the number of inversions recorded and their means and standard deviations with respect to duration, maximum, minimum, and average heights for each operational month. Heights do not refer to bottom and top of the inversion layers but to the maximum and minimum height extremes of the top of the inversion layer over the duration of the inversion. Measurements were obtained at Station 023 on the plateau from February through May 1976. Eighty-eight inversions occurred on 86 days of measurement. At Station 021 in the valley, 210 inversions were obtained on 113 days of measurement from February through May 1976. Highest frequencies of occurrence for onset times of inversions over the four-month period occurred from 1800-1930 MST for both locations. Highest frequency for times of dissipation occurred from 0800-0930 MST for the plateau site and were equally divided between this time range and 0600-0730 MST for the valley site.

A ten-day tethersonde study has been conducted on the Tract commencing on June 15 for the purposes of further identification of the vertical diffusion coefficients and wind profiles to heights beyond the projected effective stack heights. Results are expected to be presented in the next quarterly report.

II B-4 Visibility Study

The camera site and views for this study were previously shown as Figure II B-11 of Summary Report #6. Daily-mean, monthly-mean, and seasonal mean visual-ranges are reported by each of four views and for the composite of all views in this study.

Daily mean visual-ranges during the spring quarter did not exhibit the large fluctuations found during the two previous quarters. Variations in the mean visual-range of consecutive days of photography were generally

Table II B-28 TYPICAL COMPARISON OF STABILITY CLASSES FOR SPRING 1975 FLIGHT SPAN

	Stability Class @																			
	0500 MST					0800 MST					1100 MST					1700 MST				
Date	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
4/14/75	D	E		D	D	C	B		D	D	D	D	D	D	D	D	B		D	D
15	D	E		D	D	D	D		D	D	D	D	D	D	D	D	D			
16	D	D		D	D	D	C		D	D	D	D	D	D	D	D	D			
17																				
18											B	B	D	D	D	C	B		D	D
19	D	D		E	D	A	A		D	D	B	B	C	D	D	C	C		D	D
20	D	D		E	D	A	A		D	D	-	-	-	D	D	B	B		D	D
21	E	E		E	E	A	A		E	D	-	-	-			D	D		E	D
22	D	E		D	D	D	D		D	D	D	D	D	D	D	D	D		D	D
23	F	F		E	D	D	D		D	D	D	D	D	D	D	D	D		D	D
24	D	D		E	E	A	A		D	D	B	B	B	D	D	D	D		D	D
25	D	D		D	D	D	D			D	D	D	D			D	D			
26																				
27																				
28	D	D		E	D	A	A		E	D	B	A	B	D	D	C	B			
29	A	A		E	D	A	A		D	D	B	A	B	E	D	B	B			
30	D	D		E	D	A	A		D	D	A	A	B	D	D	B	B		D	D
5/1/75	E	E	-	E	E	A	A	B	D	D	C	B	C	D	D	B	B	D	D	
Average	D	D		E	D	B	B		D	D	C	C	C	D	D	C	C		D	D

Note a) Entries (left to right) are

(1) Meteorological Tower (30' to 200') corrected for wind speed (200')
(2) Meteorological Tower (30' to 200') corrected for wind speed (30')
(3) Pyranometer (daylight hours only)
(4) Aircraft T vs h slope @600' corrected for wind speed
(5) Aircraft T vs h slope @1000' corrected for wind speed

Figure II B-5
SUMMARY BY SEASON OF MEAN INVERSION ALTITUDE

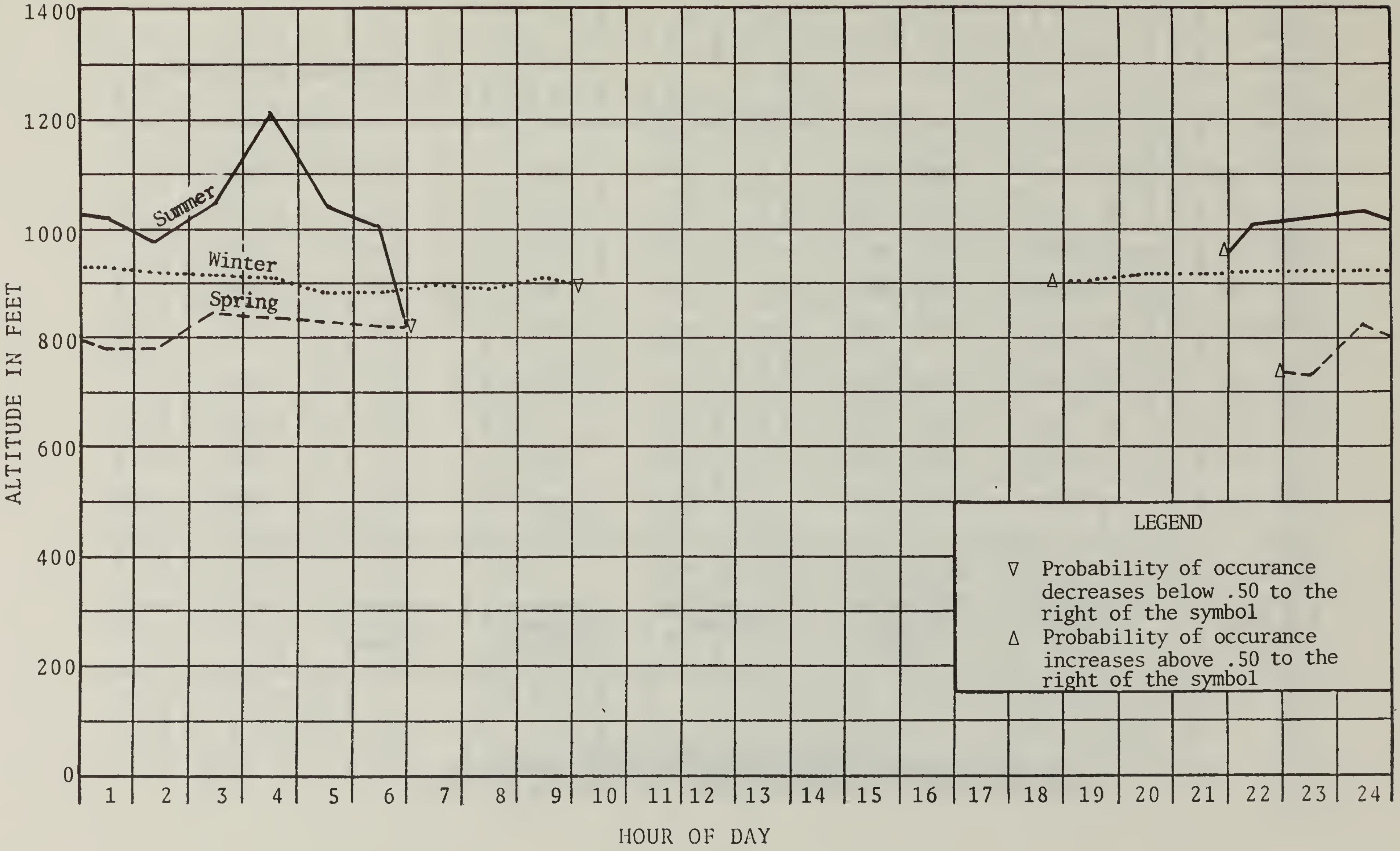

Table II B-29 MEANS AND STANDARD DEVIATIONS OF INVERSION DURATIONS AND MAXIMUM, MINIMUM AND AVERAGE INVERSION HEIGHTS BY MONTH AS OBTAINED FROM ACOUSTIC SOUNDERS

Station	Month	Number of Days of Measurement	Number of Inversions Recorded	Inversion Duration (Hrs)		Maximum Inversion Heights (Ft)		Minimum Inversion Heights (Ft)		Average Inversion Heights (Ft)	
				Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
023	Feb	28	22	12	5	994	654	290	224	607	348
	Mar	31	30	10	4	657	708	217	127	423	161
	Apr	5	8	7	3	607	202	189	39	376	76
	May	22	28	9	3	1188	444	364	246	760	335
021	Feb	24	34	14	6	726	475	199	200	509	321
	Mar	30	46	12	4	706	353	160	117	482	256
	Apr	30	63	0	4	968	365	382	189	707	272
	May	19	49	7	3	1146	472	536	258	903	402
	June[1]	10	18	7	3	1362	535	647	344	1083	484

[1] Through June 13, 1976 only.

less than 30 miles and often less than 20 miles. The only exception occurred during the first week in April when the daily mean visual-range dropped from 101 miles to 45 miles.

The daily mean visual-ranges were obtained every sixth day during the spring quarter. Mean visual-ranges varied from the mid-forties to the mid-seventies although daily mean visual-ranges near 100 miles were recorded. Fluctuations in the daily mean visual-range of the four views were generally similar in nature; an increase or decrease in the mean visual-range for an individual view was generally matched by a similar response in the remaining views. A reduction in the variation of the visual-range among the views also appears during the latter portion of the period; visual-range variations from day to day and from view to view decreased during May. Days of low mean visual-ranges, such as occurred on March 2 and April 7, were characterized by passing snowstorms which reduced visibility to less than one mile. Instances of severe restrictions to visibility, which interrupted the photographic measurements, were reported in the Site Log by the photographer. Occurrences of haze, smoke, or any condition which affected the clarity of the objects being photographed were also reported. Haze in Views I and II, for example, was often reported in the Site Log during the morning hours, and on occasion has lasted all day. On March 8, 1976, a heavy brown smoke or haze was seen in Views I and II during the morning hours and remained in View I throughout the day. Smoke was also reported to be lying in the Piceance Creek Basin towards Highway 13 during the first hour of photography, but the view cleared by mid-morning. With the exception of the smoke or haze, this day was sunny and clear; the daily mean visual-range was 61 miles. Days of high mean visual-ranges, such as April 1 and May 31, were reported in the Site Log as having little or no haze. The mean visual-ranges for these days were 101 and 88 miles, respectively.

Monthly mean visual-ranges varied little; the mean visual-range was 70 miles during March and May and 67 miles during April. Maximum values exceeded 100 miles; minimums were below 20. The general characteristics of each of the spring months along with previous data are listed in Table II B-30. The monthly composite distribution of visual-range, shown in the data report, illustrates the high frequency of low values during April and the large variation in values. Visual-ranges during March and May were distributed over a narrower range than in April.

During the spring quarter, visual-ranges were generally high; ninety-five percent of the visual range measurements were greater than 39 miles; 50 percent were greater than 67 miles. Pertinent statistics for each view and all views combined during the spring quarter (and previous quarters) are listed in Table II B-31. Maximum visual-ranges obtained during this period varied slightly among Views I, II, and III; maximum values of 118, 113, and 118 miles were recorded for the respective views. The maximum visual-range in View IV was 138 miles. Minimum visual-ranges varied among the views only slightly more than the maximum values. Minimum visual-ranges from 14 to 39 miles were recorded. The mean visual-ranges for the four views during the spring quarter were comparable ; the mean visual-range in View II was the lowest. The mean visual ranges for Views I, III, and IV were 74, 67, and 73 miles, respectively; the mean visual-range in View II was 63 miles.

Table II B-30
VISUAL RANGE (MILES) STATISTICS FOR THE COMBINATION OF ALL VIEWS FOR EACH MONTH OF MONITORING
PICEANCE CREEK BASIN, COLORADO
1975-1976

MONTH	MEAN	MAXIMUM	MINIMUM	STANDARD DEVIATION
September	77	131	42	24.0
October	89	144	44	24.6
November	99	149	24	29.0
December	86	147	17	31.1
January	72	137	27	29.2
February	84	149	25	28.2
March	70	116	27	19.2
April	67	138	14	27.7
May	70	124	27	16.7
June				
July				
August				
September				

Table II B-31
VISUAL RANGE SEASONAL SUMMARY (MILES)
PICEANCE CREEK BASIN, COLORADO

FALL, 1975

VIEW	MEAN	MAXIMUM	MINIMUM	5 PERCENTILE	STANDARD DEVIATION
I	93	149	37	49	27.8
II	77	142	42	43	23.6
III	92	146	24	46	27.4
IV	101	148	48	52	25.8
Composite	91	149	24	45	27.3

WINTER, 1975-76

VIEW	MEAN	MAXIMUM	MINIMUM	5 PERCENTILE	STANDARD DEVIATION
I	87	143	31	41	23.9
II	66	115	31	41	19.2
III	83	149	17	30	34.1
IV	86	147	22	26	35.4
Composite	80	149	17	33	30.0

SPRING, 1976

VIEW	MEAN	MAXIMUM	MINIMUM	5 PERCENTILE	STANDARD DEVIATION
I	74	118	39	50	18.9
II	63	113	32	40	16.5
III	67	118	14	25	22.3
IV	73	138	27	38	24.5
Composite	69	138	14	39	21.1

For purposes of describing the general state of visibility independent of direction, a composite distribution of all visual-range measurements during the spring quarter was made. This distribution is illustrated in Figure II B-6. Visual-ranges obtained during this period occurred most frequently between 50 and 60 miles.

To distinguish that mean value for all views during a season from the mean visual-range for an individual view, the term generalized visibility has been chosen to represent the composite mean visual-range. The term generalized visibility is the areal visibility, and the term visual-range is reserved for a single path or view. The generalized visibility in the Piceance Creek Basin area during the spring quarter was 69 miles. This value can be compared to the results of a similar study conducted over an eight month period (September 1974 - April 1975) at Grand Valley, Colorado ((Dames & Moore), 1975). The generalized visibility during that study was 86 miles.

To describe hourly trends, mean hourly visual-ranges for each view and for all views combined (Figure II B-7) have been presented to facilitate comparison of the individual trends. Hourly fluctuations in the mean visual-range of Views I and II exhibit a general similarity, with the exception of a mid-morning increase in mean visual-range in View II. The mean hourly visual-ranges in Views III and IV also exhibit a general similarity of change during the course of an average day. The visual-range in both views decreased during the morning hours, and then stabilized during the afternoon. The composite trend, shown in Figure II B-7, exhibits a slight decrease in visual-range over the course of a day.

II B-5 Noise

Monthly noise measurements are made at the 14 locations cited on Figure II C-7 of Summary Report #4 utilizing a General Radio 1565-B sound-level meter. Data for this reporting period cover the March-May months of 1976 and are contained in Quarterly Data Report #7. Average values at A-weighting are up to 78 db along Piceance Creek road in the presence of passing vehicles and 45-51 db at the on-tract sites.

II B-6 Atmospheric Diffusion Studies

As part of the input required for atmospheric diffusion models, wind persistence at specified atmospheric stability has been investigated over the first year of baseline. Monthly charts similar to the typical one shown on Table II B-32 for F stability for June 1975 are presented in Quarterly Data Report #7 for A, D, and F stability as determined from the tower data. C stability has recently been completed. Summaries of highest persistence by wind direction for A, C, D, and F stability are given on Tables II B-33 to II B-36. Longest persistence has occurred for D stability for a SSW wind on February 7, 1975, for a 27-hour duration. Maxima for both A and F have been six hours in any given sector.

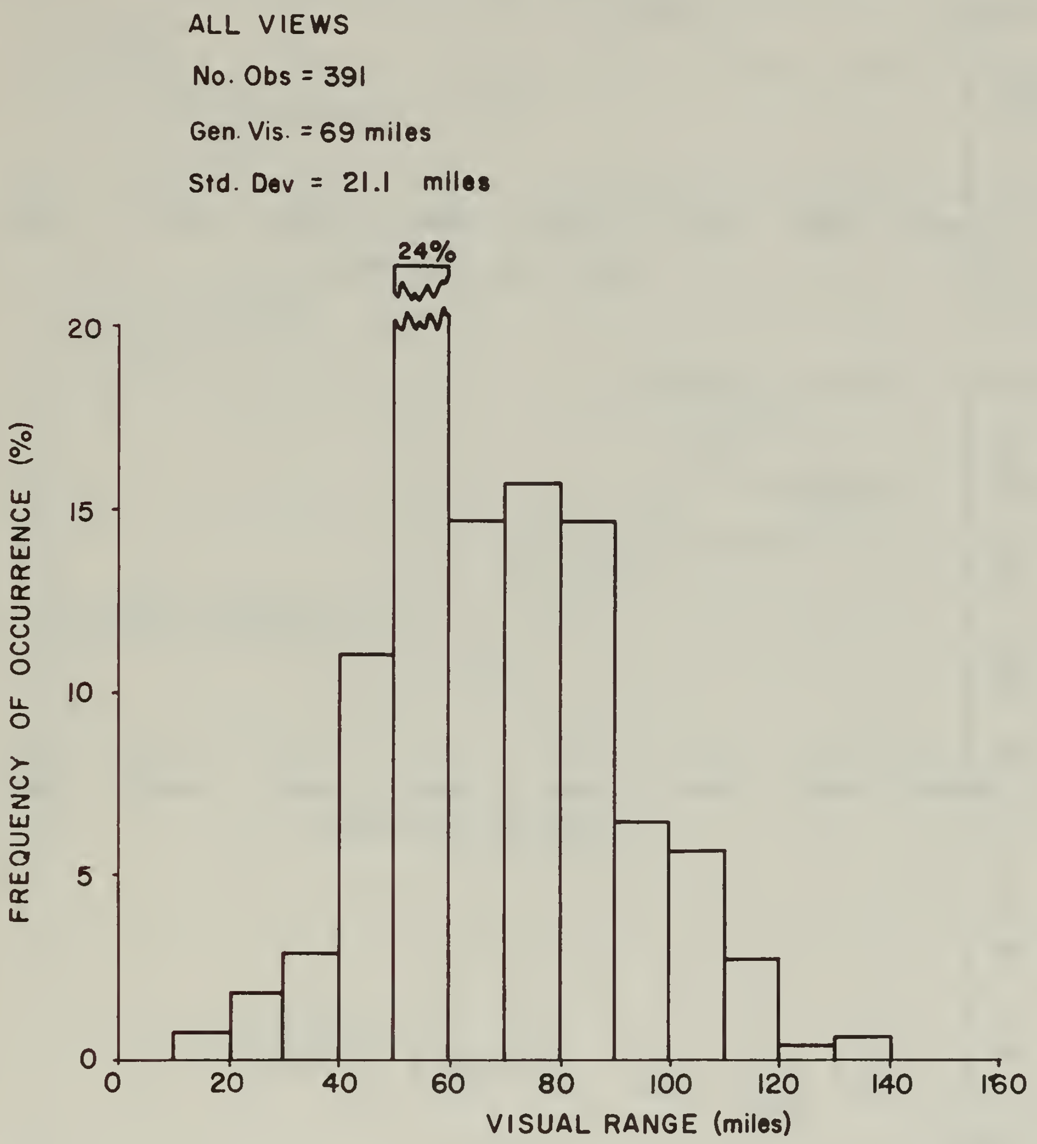

Figure II B-6

**COMPOSITE VISUAL RANGE DISTRIBUTION
PICEANCE CREEK BASIN, COLORADO
SPRING, 1976**

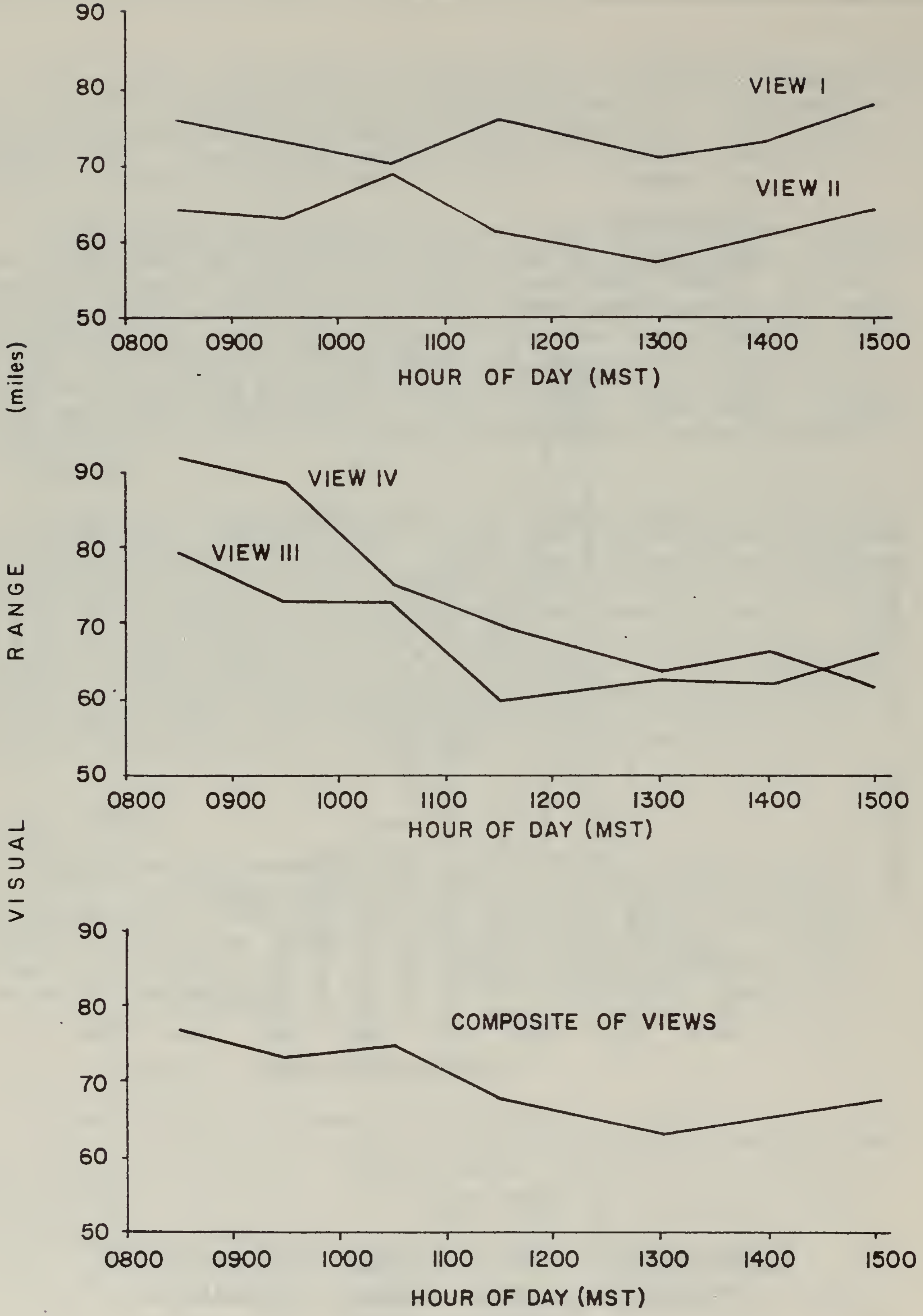

Figure II B-7

VARIATION IN THE MEAN HOURLY VISUAL RANGE
PICEANCE CREEK BASIN, COLORADO
SPRING, 1976

Table II B-32

WIND PERSISTENCE AT SPECIFIED STABILITY

STABILITY F
MONTH June
YEAR 1975

UNITS: V(MPH); D(SECTOR)

DAY	SPEED DIR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	V		2				2															3	3	3	1
	D		SSW				NNE															S	S	S	W
2	V	2	1	1	1	2	1	3																13	
	D	NE	NNE	ENE	N	ESE	ESE	E																SSE	
3	V	4	3	3	3	2	0																		
	D	E	SW	S	SSE	NW																			
4	V																								1
	D																								NE
5	V	6			0	1																1	3	4	4
	D	NE				NW																SSW	SSW	S	S
6	V	3	4	3	3	1	4																6	6	3
	D	S	SSW	SSW	SSW	SSW	WNW																SE	S	S
7	V	5	7	8		5	3	3																	
	D	S	SW	SSW		SSW	N	N																	
8	V																								
	D																								
9	V																								
	D																								
10	V																								
	D																								
11	V																								
	D																								
12	V		2		2	5	8																		
	D		SSW		SE	S	SSW																		
13	V																								
	D																								
14	V																								
	D																								
15	V																								
	D																								
16	V																								
	D																								
17	V																								
	D																								
18	V																								
	D																								
19	V																								
	D																								
20	V				1		3	3																	
	D				WNW		WSW	S																	
21	V		4																						
	D		SE																						
22	V																					8	7	9	
	D																					SSW	SSW	S	
23	V	2	1	2	3	4	10																		
	D	SSE	SE	E	SE	SE	SSE																		
24	V																								
	D																								
25	V																								
	D																								
26	V																								
	D																								
27	V																								
	D																								
28	V																								
	D																								
29	V																								
	D																								
30	V																								
	D																								
31	V																								
	D																								

Sources: V,D from Tower @ 200'; Stability from ΔT (200'-30') corrected for wind speed

Table II B-33

STABILITY A
WIND PERSISTENCE
(Nov. 1974 - Oct. 1975)

Direction	Max. Duration Hrs.	Date				
N	2 2	6/5/75 9/29/75	2	10/2/75	2	10/3/75
NNE	3	1/11/75				
NE	2	10/15/75				
ENE	2	1/1/75	2	9/8/75		
E						
ESE	2	1/12/75				
SE	2	5/21/75				
SSE	3	5/5/75				
S						
SSW						
SW						
WSW						
W	3	4/12/75				
WNW	6	10/27/75				
NW	4	10/24/75				
NNW	2	1/10/75	2	5/2/75	2	10/2/75

Table II B-34
STABILITY C
WIND PERSISTENCE
(Nov. 1974 - Oct. 1975)

Direction	Max. Duration Hrs.	Date				
N	2	9/20/75				
NNE	2	9/30/75				
NE						
ENE						
E						
ESE						
SE						
SSE						
S						
SSW	4	3/18/75	4	5/15/75		
SW	3	4/9/75				
WSW						
W						
WNW	2	4/11/75				
NW	8	10/23/75				
NNW	3	5/29/75				

Table II B-35
STABILITY D
WIND PERSISTENCE
(Nov. 1974 - Oct. 1975)

Direction	Max. Duration					
	Hrs.	Date				
N	3	6/3/75				
NNE	4	4/26/75				
NE						
ENE						
E	2	8/21/75	2	10/14/75		
ESE						
SE	2	3/23/75	2	4/3/75	2	6/19/75
SSE	4	3/25/75	4	10/10/75		
S	14	5/4/75	12	4/25/75	11 11	4/25/75 10/11/75
SSW	27	2/7/75	25	10/26/75	15	3/21/75
SW	10	4/22/75	9	8/23/75		
WSW	3	4/18/75	3	5/15/75		
W	4	1/25/75	4	4/12/75		
WNW	5	1/7/75	5	2/15/75		
NW	6	1/8/75	4	4/26/75		
NNW	4	1/9/75	4	1/21/75		

Table II B-36
F-STABILITY WIND PERSISTENCE (Nov. 1974 - Oct. 1975)

Direction	Max. Duration Hrs.	Date				
N	2	6/7/75	2	10/18/75		
NNE	2	6/4/75	2	9/22/75		
NE	2	8/9/75	2	8/30/75		
ENE	2 2	5/17/75 8/10/75	2 2	8/29/75 9/22/75	2	9/24/75
E	3	1/23/75	3	8/3/75		
ESE	3	2/17/75	3	8/3/75	3	9/5/75
SE	4	5/14/75	4	8/10/75		
SSE	3	8/4/75	3(1)	10/6/75	3	10/24/75
S	5	1/19/75	4 4	5/6/75 9/3/75	4(1) 3(2)	10/6/75 6/5/75
SSW	6(2)	6/5/75	5	10/5/75		
SW	4	1/23/75	4	9/6/75		
WSW	3	8/2/75				
W	2	8/8/75	2	9/4/75	2	9/27/75
WNW	3	9/17/75	3	9/21/75		
NW	2 2	1/1/75 1/29/75	2	8/2/75	2	8/29/75
NNW	2	1/1/75	2	9/29/75		

(1) 3^h @SSE & 4^h @S
(2) 6^h @SSW & 3^h @S

II C BIOLOGY

II C-1 Terrestrial Wildlife Studies

Big Game

Mule Deer Habitat Utilization

Field studies of key browse plants are presently being conducted. The plants receiving most emphasis include antelope bitterbrush, mountain mahogany, big sagebrush, and serviceberry. Final analysis of browse studies will include an estimate of percent utilization by deer based on shoot length measurements of browsed and unbrowsed shrubs.

Deer pellet-group counts were conducted during May shortly after the deer had begun their migration to higher summer range. The results of the pellet-group counts (Table II C-1) indicate an appreciably higher use per acre by deer of the chained pinyon-juniper habitat type than of the remaining three habitat types sampled.

Mule Deer Movement Patterns

Deer road count studies were completed this quarter. The two years of deer road count data (the winters of 1974-75 and 1975-76) showed similar patterns of deer distribution over the 36-mile length of road which was routinely traveled between Rio Blanco and Little Hills Game Experiment Station. During both years the highest concentrations of deer tended to be in the meadows adjacent to the Tract C-b area. However, these high concentrations are seasonal inasmuch as the meadows were frequented by large numbers of deer during October and November and again from mid-March to early May. During both years the sparsely vegetated south-facing slopes were mainly used in January and February when snow conditions were most severe.

Some differences exist, however, between this past quarter's deer road counts (Table II C-2) and the data obtained in 1975. More deer were observed this spring than during the spring of 1975. Along the length of road which borders the study area, there were an average of 100 deer per mile on April 22, 1976, the date of maximum concentration in 1976. On May 2, 1975, the date of maximum concentration in 1975, an average of 77 deer per mile was calculated from counts made along the same six-mile distance. In addition, there was little indication in 1976 that spring meadow concentrations shifted in a down-stream direction as the fall-spring seasons progressed.

The spring migration of deer from the Tract C-b area was studied during May. The main objective was to estimate the relative amount of deer travel occurring along the major north-south ridges in the Tract C-b study area (Table II C-3). Deer left the Tract C-b area and began moving to higher summer range during the first week of May, approximately one

Table II C-1. MULE DEER PELLET-GROUP COUNTS CONDUCTED MAY 1976.

	Habitat Type				
	Pinyon-Juniper	Chained Pinyon-Juniper	Upland Sage-brush	Valley Sage-brush	Total
Number of plots (0.01 acres each)	440	182	96	132	850
Area sampled (acres)	4.40	1.82	0.96	1.32	8.5
Number of pellet-groups	1644	860	321	372	3197
Pellet-groups					
(/acre)	373.6	472.5	334.4	281.8	
(/hectare)	923.2	1167.6	826.3	696.3	

Table II C-2. MULE DEER ROAD COUNTS CONDUCTED MARCH, APRIL, AND MAY 1976.

			Number of Deer Observed										
			March				April					May	
Mile Interval		Location	9	12	16	29	6	13	22	24	28	4	10
1		Little Hills											
2			2				14	81	57	61	58	22	
3					24	51	4	45	28	69	46		
4					5		108	139	175	102	99	8	
5			14		3	34	2	54	26	48	28		
6			12	9	16	8	85	72	30	26	45		
7					28	23	9	30	40	28	5	3	
8			3		7		18		58	75	10		
9		Ryan Gulch					7	114	2	62		4	
10			17	4	13		97	39	42	117	47	5	
11			5		11		20	4	54	8			
12		Black Sulphur Cr.	1		8	18	3	31	21	45		4	
13			5		5	56	17	78		24			
14		Hunter Creek		1	8	23	82	111	44	69			
15	Tract C-b study area				25	83	102	107	78	69		7	
16		Willow Creek	14		22	32	153	64	164	152			
17					18	91	44	17	79	91		17	6
18		Sorghum Gulch	4		25	42	132	172	164	66	143		
19			7		7	12	24	46	48	41	91	8	
20		Stewart Creek			10	15	36	50	68	86	86		
21					4		28	11	68	50	60		
22			17	19	23	37	16	63	59	55	15		
23			34	7	19	6	55	78	30	57	57		
24			21	23	11	8	65	36	50	16	53		
25		Story Gulch	13		3	7	56	6	38	38			
26			16	1	6		11	10	62	46	24		
27			4		7	9	15	13	6				
28				1		6	5		21	4			
29										5			
30			4										
31								4					
32			7	11									
33													
34													
35													
36		Rio Blanco											
		TOTALS	200	76	308	561	1208	1475	1512	1510	867	78	6

Table II C-3 MULE DEER TRACK COUNTS CONDUCTED ON SIX MAJOR NORTH-SOUTH RIDGES LEADING SOUTH FROM TRACT C-b.

Ridges	Number of tracks crossing a one-km continuous transect
West of Willow Creek	47
Between Willow Cr. and Scandard Gulch	25
Between Scandard and Sorghum Gulch	35
Between Sorghum Gulch and West Stewart Creek	47
Between West and Middle Stewart Creek	30
Between Stewart Cr. and Piceance Creek	22

NOTE: Counts were made May 6, 1976, during the spring deer migration from the tract area.

week earlier than in 1975. Immediately following the initial spring migratory movement, a count was made of deer tracks that crossed five one-km transect lines. These lines were located on five ridges (one per ridge) which lead south from Tract C-b. All lines were positioned perpendicularly to the ridges and were located in similar pinyon-juniper habitat at approximately 7000 ft. elevation. All tracks counted were less than 27 hours old and were easily recognizable as such because of a rain storm the day before.

This study shows that all the ridges examined are used by deer as travel routes, although two ridges may have been traveled by appreciably more deer than the remaining four during the time of this study. The two heavily traveled ridges are west of Willow Creek and west of West Stewart Creek.

Mule Deer Mortality Studies

A deer age-class estimation was conducted on April 15, 1975. The ratio of fawns to adult deer was determined by observations of deer feeding in the meadows along Piceance Creek north of Tract C-b. The observed ratio of fawns to adults was 196:299, or 65.6 fawns to 100 adults.

Medium-sized Mammals

The bi-monthly track counts of the medium-sized mammals (and deer) were conducted in March and May. Results are presented in Table II C-4. Counts during May were conducted on dry, dusty soil.

Long-tailed weasels were recorded again this quarter, and one sighting was made by personnel conducting ornithological studies. Cottontail tracks again showed low frequencies of occurrence, and no jackrabbit tracks were recorded. The incidence of coyotes was lower than expected; field observations indicated that coyotes were common throughout the spring quarter. One coyote-deer kill was reported by field investigators who found a newly killed fawn. The evidence supporting a predator kill included subcutaneous bleeding in the head region, scattered patches of hair on the trail along which the animal had run prior to being pulled down, and coyote tracks in the fresh snow. The possibility that dogs were responsible or that the fawn had been injured by a vehicle seemed unlikely.

Small Mammals

During the April field survey small mammals were livetrapped at satellite grids and grids 1 and 2. The percentage of reproductive animals was relatively high compared to data collected during April 1975. The initiation of reproductive activity may be related to mild weather during the late winter and early spring. Preliminary analysis of data

Table II C-4 PERCENT FREQUENCY* OF TRACKS FROM COUNTS CONDUCTED ON MARCH 3, AND MAY 9, 1976

Habitat Type	No. of Quadrats		Deer		Coyote		Cottontail		Other	
	Mar.	May	Mar.	May	Mar.	May	Mar.	May	Mar.	May
Pinyon-juniper woodland	100	16	0	18.7	0	12.5	0	0	6.3**	0
Chained pinyon-juniper	100	20	4	5.0	0	0	0	0	5.0**	0
Valley sagebrush	100	20	8	0	0	0	0	40	0	0
Lower valleys and agricultural meadows	100	18	1	0	0	0	0	11	0	0

---

* Percent frequency $= \left(\frac{\text{No. Q w/Tr.}}{\text{No. Q in Hab.}}\right) \times 100$

** Long-tailed weasel, *Mustela frenata* collected during the May 1976 trapping effort revealed a large number of subadult animals which represents an early spring litter.

Reptiles and Amphibians

The number of lizards observed during the May 1976 sampling period was relatively low. The probable causes of the observed low lizard activity were cool temperatures and cloud cover that occurred during the May sampling period.

Arthropods

During the May sampling period arthropods were collected from pit cans on grids 1 and 2 and by sweep netting the major shrub species. These data have not been analyzed and will appear in the Eighth Quarterly Report.

II C-2 Aquatic Studies

The aquatic studies for this quarter included bimonthly sampling of fish, benthos, periphyton, water samples, sediments, and plankton. Collections were made in March and May. Upper Stewart Lake was frozen over in March.

Fish

No new fish species were collected during this quarter. Rainbow trout, brook trout, brown trout, mountain whitefish, mountain sucker, flannelmouth sucker, mottled sculpin, and speckled dace were collected in the streams (Tables II C-5 and II C-6). Fourteen tagged brook trout were recaptured. Population estimates were made for brook trout by the Petersen method and for brook trout and mountain suckers by the DeLury method. Fecundities were computed for brook trout, mountain suckers, and speckled dace. Food habits were examined for brook trout, mountain suckers, and mountain whitefish by stomach-contents analysis (Tables II C-7 and II C-8). Ages of selected mountain suckers and brook trout were determined by scale readings.

Benthos

Benthic invertebrates were represented by three phyla: Annelida, Arthropoda,and Mollusca. The arthropods were most abundant. Dipterans, ephemeropterans, plecopterans,and trichopterans were increasing in numbers in May. The mean biomass varied from 0.149 gm/ft^2 to 3.7144 gm/ft^2. Species diversity values ranged from 0.465 at Station W-2 to 3.067 at Station W-1 in March and from 1.135 at Station UWL to 3.241 at Station S-2 in May.

Table II C-5 NUMERICAL ABUNDANCE OF SPECIES OF FISH CAPTURED DURING MARCH 1976 FROM PICEANCE, STEWART AND WILLOW CREEKS, AND THE WHITE RIVER

	Species								
Station	Brook Trout	Brown Trout	Rainbow Trout	Mountain Whitefish	Speckled Dace	Mountain Sucker	Mottled Sculpin	Flannelmouth Sucker	Total
Piceance Creek									
P-1	1				2	18			21
P-2	1		1		1	8			11
P-3	3				1	6			10
P-5					2	2			4
P-5A	5	1	1		1	4			12
P-6	2					3			5
P-7									0
Stewart Creek									
S-1	5								5
S-2	14								14
LSL	11								11
Willow Creek									
W-2									0
W-3									0
White River									
WR-1								1	1
WR-2				7	1		2		10
TOTALS	42	1	2	7	8	41	2	1	104

Table II C-6 NUMERICAL ABUNDANCE OF SPECIES OF FISH CAPTURED DURING MAY 1976 FROM PICEANCE, STEWART AND WILLOW CREEKS, AND THE WHITE RIVER

	Species							
Station	Brook Trout	Rainbow Trout	Mountain Whitefish	Speckled Dace	Mountain Sucker	Mottled Sculpin	Flannelmouth Sucker	Total
Piceance Creek								
P-0				16	26			42
P-1	2			1	8			11
P-2	3	2		5	5			15
P-3	5			14	38			57
P-5		1		5	7			13
P-5A	2	1		5	10			18
P-6				4	5			9
P-7				3				3
Stewart Creek								
S-1	4							4
S-2	16							16
LSL	21							21
Willow Creek								
W-2					7			7
W-3								0
White River								
WR-1			1	1		1	2	5
WR-2			2	1				3
TOTALS	53	4	3	55	106	1	2	224

Table II C-7 FOOD* OF BROOK TROUT COLLECTED FROM PICEANCE CREEK AND LOWER STEWART LAKE DURING MARCH AND MAY 1976

	Fish #1**			Fish #2**			Fish #3**		
	Sex	Length	Wt	Sex	Length	Wt	Sex	Length	Wt
Stomach Contents	F	227 mm	103 g	M	147 mm	42 g	M	300 mm	224 g
Diptera									
Tipulidae					1				
Chironomidae		17						8	
Culicidae		≈250							
Ephemeroptera									
Baetidae									
Ephemerella					2				
Trichoptera									
Limnephilidae									
Hesperophylax					2				
Brachycentridae									
Brachycentrus					1				
Amphipoda									
Gammaridae									
Gammarus					2				
Plecoptera									
Isoperla					21				
Homoptera									
Cicadellidae*** (Leafhopper)					1				
TOTAL INSECTS		267			30			8	
TOTAL STOMACH VOLUME		.5 ml			2.5 ml				

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* Number of Individuals

** Fish #1 & #2 taken in May 1976; Fish #3 taken in March 1976

*** Terrestrial

Table II C-8 FOOD* OF MOUNTAIN WHITEFISH AND MOUNTAIN SUCKER COLLECTED FROM THE WHITE RIVER AND PICEANCE CREEK DURING MARCH 1976

	Mountain Whitefish**			Mountain Sucker***		
	Sex	Length	Wt.	Sex	Length	Wt.
Stomach Contents	M	137 mm	24.5 g	F	145 mm	40.5 g
Diptera						
Chironomidae		6			2	
Simuliidae		1				

NOTE: Insect volume was too small to measure; algae were present but not identified

---

* Number of Individuals

** Taken from the White River

*** Taken from Piceance Creek

Periphyton

Diatoms and green algae were collected from periphyton samplers in March and May. Diatoms were the most numerous species collected. Periphyton primary productivity was greatest in Piceance Creek in March and May at Station P-3, and lowest at the downstream station (P-6). The greatest periphyton productivity occurred in Stewart and Willow Creeks in May.

Plankton Primary Productivity

Phytoplankton primary productivity was measured in March and May in the lakes using the light and dark bottle method. Differences between the light and dark bottle were slight or negligible in March. In May there was a significant difference between light and dark bottles. The amount of carbon fixed, which is an indication of the amount of photosynthesis, was computed for May samples. The amount of carbon fixed varied from 66.6 mg/m^2 to 536.5 mg/m^2 for a 21-hour period.

Water Quality

Water quality samples were analyzed for common minerals and nutrients, total hardness, total alkalinity, total dissolved solids, bacteria, and pathogens. Total dissolved solids were increasing in March and May. Coliform levels increased significantly during spring. No disease pathogens were detected in the samples from the stations examined.

Sediment

Sediment grain size analysis was conducted in March and May at selected stations. In general there was an increase in fine sediment particles in spring compared to January.

Springs and Seeps

Seven springs and seeps were sampled in March. In most cases, invertebrates collected in the springs and seeps are also found at the other aquatic sampling stations. A few new species were collected in March.

Plankton

Plankton samples were collected from all stations in March and May. Samples were preserved and stored for later analysis.

II C-3 Terrestrial Vegetation Studies

Based on examination of repeated measurements of marked shrub twigs (Table II C-9), the following observations about the growth characteristics of the major shrub species have been made.

Serviceberry (*Amelanchier alnifolia*). Stem growth in chained rangeland fenced plots was 3.1 times greater than in fenced pinyon-juniper plots and 4.6 times greater than in the open plots. In the chained sites the average total shoot growth was 1.4 times greater in the fenced plots than it was in the open plots. In the pinyon-juniper woodland sites the average total shoot growth was 2.1 times greater in the fenced plots than it was in the open plots. Lateral shoot growth was 1.6 times greater in the open chained plots than in the fenced plots. Lateral shoot growth was 1.3 times greater in the open pinyon-juniper plots than in the fenced plots. Average main twig length increase during the 1975 growing season in the fenced chained plots was 48 percent of 1974 lengths. Main twig growth in the open plots in the chained areas amounted to a 60 percent decrease at Plot 1 and a 1.8 percent increase at Plot 2. The decreases most likely result from browse damage from large herbivores during the winter of 1974-1975. Main twig increases in the pinyon-juniper fenced sites amounted to an average of 70.5 percent increase based on 1974 measurements, i.e. September 1975 lengths were 70.5 percent greater than September 1974 lengths. Growth in the open plots amounted to a mean increase of 5.8 percent.

Mountain mahogany (*Cercocarpus montanus*). Stem growth in fenced chained rangeland sites was 2.5 times greater than in fenced pinyon-juniper sites (Plot 5). In the open plots in the chained rangelands, the mean increase in total stem length was 35.2 mm; in the pinyon-juniper plot there was a net decrease of 21.5 mm. In the chained sites total growth in the fenced plots was 81 times greater at Plot 1 and 2.6 times greater at Plot 2 than in the open plots. In the pinyon-juniper plots there was a net mean increase of 85.8 mm in the fenced plot and a net decrease of 21.5 mm in the open plot. Lateral shoot growth was 5.1 times greater in the fenced plot than in the open plot at chained Plot 1, but was 1.8 times greater in the open sampling area at Plot 2. At the pinyon-juniper site lateral shoot growth was 2.5 times greater in the fenced plot than in the open plot. During the 1975 growing season the average increase in the main twig length was 45 percent above the fall 1974 measurements at the fenced chained plots (1 and 2). In the open plots at these sites the main twigs showed an average decrease of 45 percent during this same time period (September 1974-September 1975). Losses result primarily from browse damage. In the pinyon-juniper site (Plot 5) the increase in the fenced plot was 94 percent and the decrease in the open plot was 47 percent during this time period.

Big sagebrush (*Artemisia tridentata*). Total growth in the fenced bottomland and upland fenced plots was essentially the same, however the growth in the bottomland open plot was 4.7 times greater than that in the upland plot. In the bottomland plots total stem increases were

Table II C-9 . Marked twig measurements. Length in millimeters; ± values are equal to the standard error of the mean. n = the number of observations used in calculating means. N-values vary since some of the tags marking the twigs have been lost.

Species	Plot	$\bar{x}$ main twig length 9/74 (n=20)	$\bar{x}$ main twig length 6/75	$\bar{x}$ main twig length 9/75	$\bar{x}$ increase in main twig 9/74-9/75	$\bar{x}$ increase in lateral shoots 9/74-9/75	Total increase in twig length (main twig plus laterals) 9/74-9/75
Amelanchier alnifolia	1-F	87.1±10.9	121.5±15.5 n=19	128.3±15.8 n=18	41.2	72.3±21.7 n=14	113.5
	2-F	137.7±11.6	173.3±18.4 n=20	205.2±25.0 n=20	67.5	110.4±25.4 n=20	177.9
	5-F	41.6± 5.7	71.7±10.5 n=20	75.6±11.7 n=20	33.9	11.9± 4.2 n=20	45.8
	6-F	49.0±11.2	72.4±17.0 n=20	78.3±18.1 n=20	29.3	19.6± 9.6 n=20	48.9
	1-O	90.4±16.6	35.7± 8.4 n=14	36.2± 9.2 n=13	-54.2	120.6±52.6 n=13	66.4
	2-O	149.8±22.3	129.5±24.5 n=17	152.5±37.4 n=17	2.7	151.2±49.3 n=17	153.9
	5-O	57.0± 7.8	54.4±14.4 n=16	57.5±16.2 n=16	0.5	16.9± 7.2 n=16	17.4
	6-O	66.7± 8.6	67.6±13.7 n=20	73.8±16.9 n=20	7.1	23.4± 7.6 n=20	30.5
Cercocarpus montanus	1-F	152.2±20.0	156.5±20.9 n=19	224.7±35.1 n=19	72.4	186.4±76.9 n=19	258.8
	2-F	186.1±25.4	194.4±25.2 n=20	266.0±30.5 n=19	80.0	97.0±44.2 n=19	177.0
	5-F	59.0± 8.4	60.4±10.9 n=18	114.2±29.1 n=18	55.1	30.7±18.0 n=18	85.8
	1-O	94.2±10.0	31.1±12.1 n=13	60.9±32.9 n=13	-33.3	36.5±22.7 n=13	3.2
	2-O	200.5±15.6	87.8±17.8 n=18	89.7±18.2 n=18	-110.8	177.9±44.1 n=18	67.1
	5-O	72.2±10.3	11.5± 4.3 n=15	38.5±23.4 n=12	-33.7	12.2± 7.9 n=12	-21.5
Artemisia tridentata	3-F	32.8± 4.5	34.0± 5.8 n=19	42.1± 8.4 n=18	9.2	72.5±32.0 n=18	81.7
	4-F	42.9± 6.5	50.4± 6.2 n=19	59.7± 7.7 n=17	16.7	65.8±26.2 n=17	82.5
	3-O	26.5± 3.5	15.5± 6.2 n=12	17.5± 8.0 n=11	-9.0	26.2±26.0 n=11	17.2
	4-O	57.6± 8.0	66.2±10.6 n=18	72.4±11.1 n=18	14.7	66.5±39.4 n=18	81.2

essentially the same in fenced and open plots. In the upland plots growth was 4.8 times greater in the fenced plot than in the open plot. Lateral shoot growth was essentially the same in the fenced and open bottomland sagebrush plots. In the upland plots lateral shoot growth was 2.8 times greater in the fenced plots. Increases in main twig lengths in the bottomland plots were 39 percent in the fenced plot and 26 percent in the open plot. In the upland site mean main twig increases were 28 percent in the fenced, however, there was an average decrease of 34 percent in the open plot. The decrease most likely resulted from browse damage.

II C-4 Soil Survey and Productivity Assessment

Plan completed.

II D GEOLOGY

The surface geology report was presented in Quarterly Data Report #5 and in the Annual Summary and Trends Report. Data pertaining to surface geology will be integrated, as it applies to other studies, within Section II E - Ecological Interrelationships.

II E ECOLOGICAL INTERRELATIONSHIPS

The section on Ecological Interrelationships was introduced in the Annual Summary and Trends Report and expanded upon in Summary Report #6. Continuing study of this area has not progressed to the point that additional reports can be made in this summary report.

III A FISH AND WILDLIFE MANAGEMENT PLAN

Plan Completed.

III B REVEGETATION PROGRAM

Seeding Program

During the 7th Quarter, seeding of the following areas was accomplished: Drill pad, SG-8, critical areas SG-21 and A-13, the Aquifer Test Pad, and all soil trenches. These areas were prepared and seeded according to plans previously submitted and approved. The only change was the elimination of Arrowleaf balsamroot (*Balsamorhiza sagittata*) at the request of the Area Oil Shale Supervisor and the Bureau of Land Management.

Additional broadcast seeding on drill pads prepared and seeded in the fall of 1975 was also done during this quarter. This additional work is appropriately noted on plans previously submitted and approved. This seeding was not supplemental, but was delayed as the result of seed availability. Snowberry (*Symphoricarpos oreophilus*), thickspike wheatgrass (*Agropyra dasystachyum*), and yellow sweetclover (*Melilotus officinale*) were broadcast during this quarter to complete the seeding on drill pads.

SG-20 was not seeded as planned during the past quarter. The design of the original plan has been altered through cooperative discussions with the Bureau of Land Management. Preparation and seeding of this area will be done in the coming fall.

Processed Shale Revegetation

The successful revegetation of processed shale produced during the retorting of shale oil by the TOCSO II method has been under study since 1963. The majority of this research has been conducted at the Colony Development Operation site in Parachute Creek, although other studies have been underway for several years in other areas, noteably the PARAHO facility and in the Piceance Basin. Since it has been proven to be successful, much of the methodology derived from the results of the Colony studies will be used by the C-b Shale Oil Project in the revegetation of spent shale on Tract C-b. Methodologies derived from other successful studies will also be incorporated. The latest published results of the Colony studies are being included in this quarterly report to keep interested readers informed on the progress being made in spent shale revegetation. The following narrative is taken verbatim from *Revegetation of TOSCO II Processed Shale* by The Oil Shale Corporation. Four of six photographs in the report have been selected as the most visually descriptive and included herein as Figures III B-1 through III B-4. Please note the tree in the background of each picture. This tree can be used for orientation.

Over 60 species of grasses, shrubs, forbs, and trees have been successfully grown in processed oil shale from the TOSCO II retorting system during more than a decade of revegetation studies. These have included laboratory, greenhouse, and large-scale field tests conducted by TOSCO and its partners in the Colony Development Operation*. The photographs on the following pages show the progress of an experimental processed shale embankment established in the spring of 1971 in the East Middle Fork of Parachute Creek, about 16 miles north of the town of Grand Valley in northwestern Colorado. The plot is at an elevation of about 6,000 feet.

The processed shale, wetted as it came from the retort, was laid in two-foot terraced levels in the embankment and compacted to a density of about 80-90 pounds per square inch. Salts naturally present in the shale were leached to below the plant root zone by watering. The surface was then planted and overlaid with mulch material such as straw to hold water and prevent damage from excessive solar heating. Among the mixture of species planted were wheatgrass, Russian wildrye, yellow sweet clover, four-wing salt bush, and Indian ricegrass. Regular watering of the plants was continued only through the first two growing seasons. Since then the vegetation has been self-sustaining and is in the process of natural succession.

The cost of the revegetation program being planned for a commercial size oil shale operation is estimated at approximately $3,000 per acre, or less than 1/10 of a cent per barrel of oil produced. This includes adding a six-inch soil cover atop the shale embankment to help protect plant seedlings and enhance their initial growth.

Of the 17 nutrients necessary for plant growth, processed shale lacks just two, phosphorus and nitrogen. Testing by Colony Development Operation on this 1971 plot and at other field sites indicates that an initial application of 500 pounds of phosphorus fertilizer per acre and 70 pounds of nitrogen fertilizer per acre are required to successfully establish plant growth. An additional 70 pounds of nitrogen per acre is needed for the following two years.

An interesting sidelight is that a 50,000 barrel-a-day oil shale complex itself will produce -- as a byproduct -- five thousand times more nitrogen fertilizer than is needed for the revegetation program. While an average of eight tons of nitrogen fertilizer will be needed yearly to revegetate the processed shale embankment created over the life of the shale plant, each year the complex will produce more than 44,000 tons of nitrogen fertilizer in the form of anhydrous ammonia. This byproduct is a result of upgrading the shale oil prior to its being pipelined.

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* A joint venture of TOSCO, Ashland Oil Inc., Shell Oil Company and Atlantic Richfield Company (Operator).

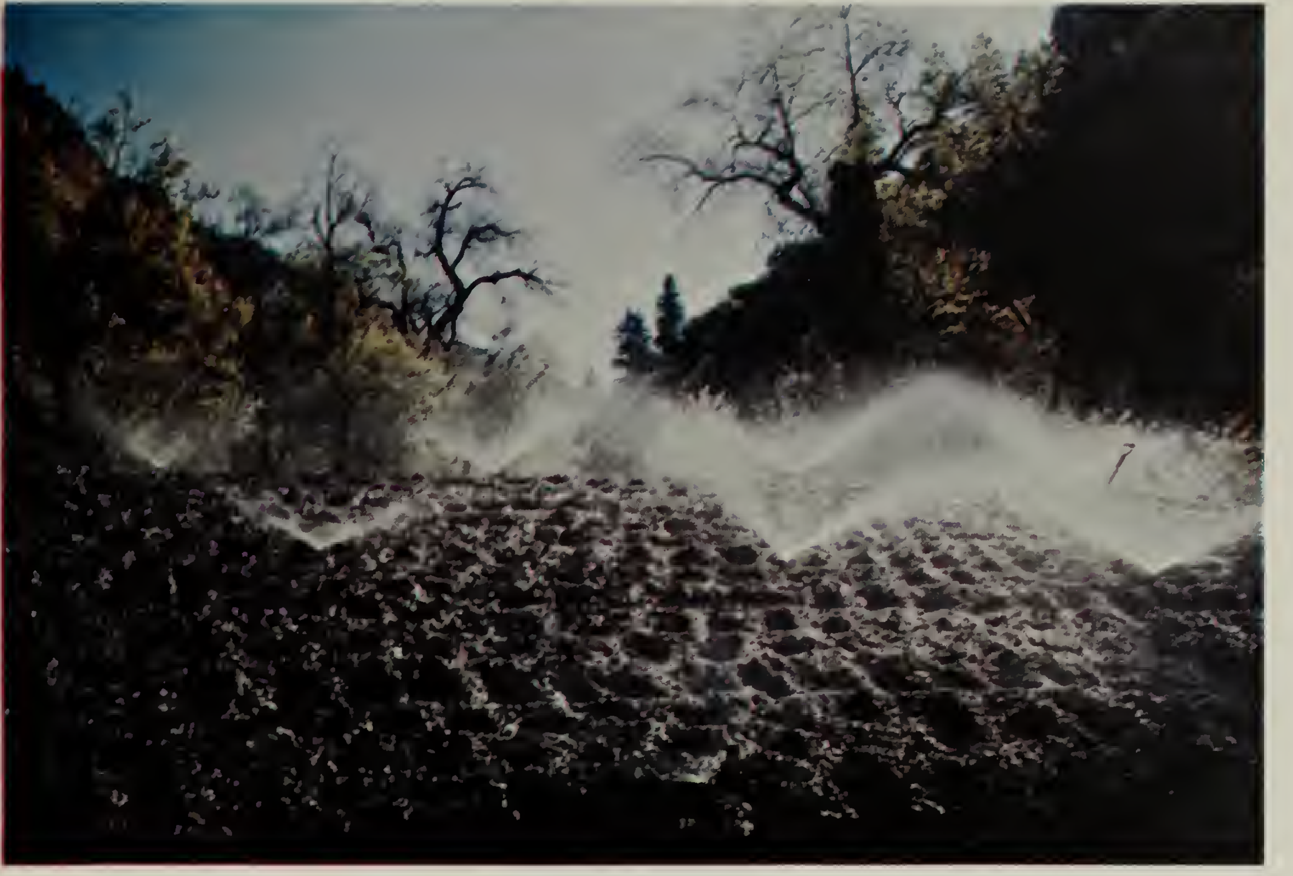


Figure III B-1

WATERING TO LEACH SALTS DOWN BELOW THE PLANTS' ROOT ZONE

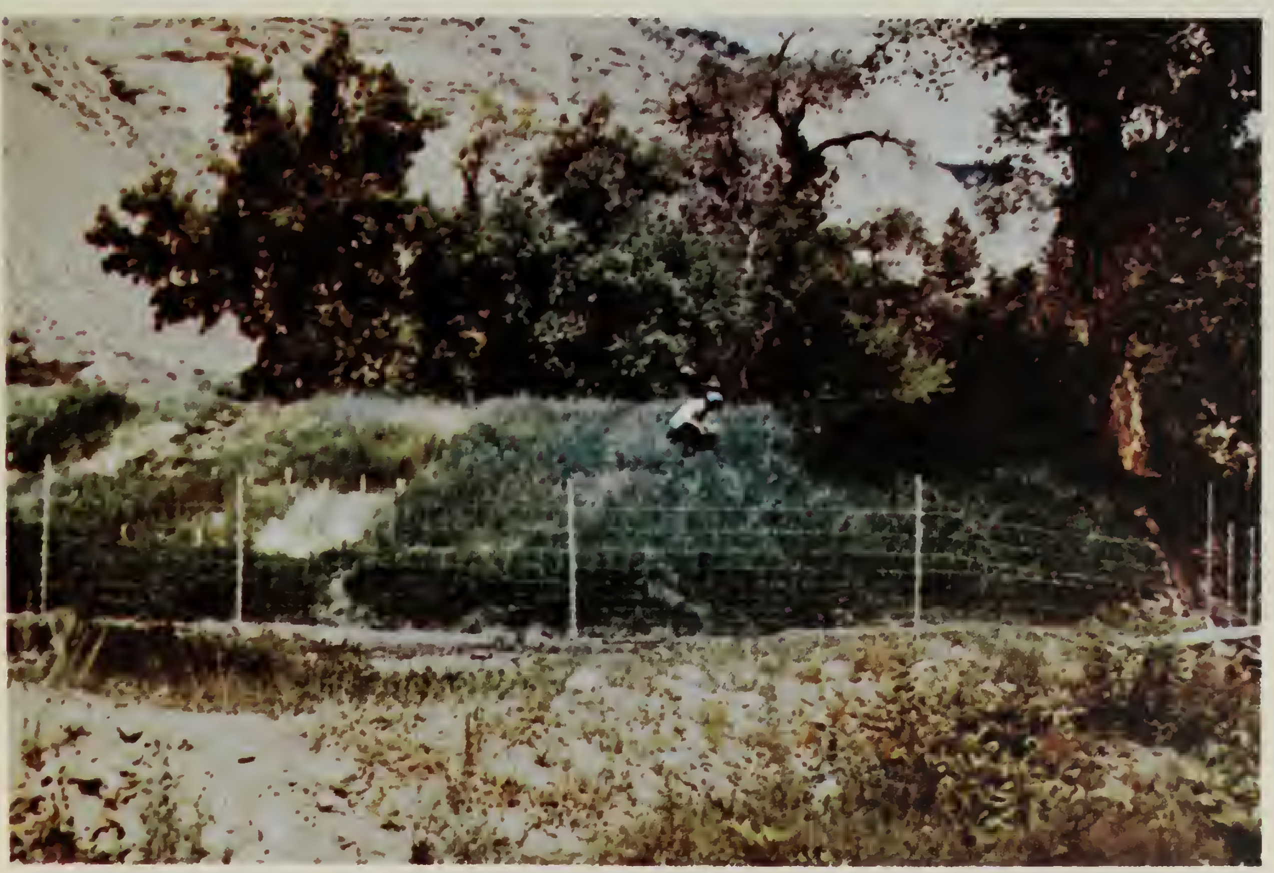


Figure III B-2

VEGETATION AFTER THE FIRST GROWING SEASON (SEPTEMBER 1971 PHOTO)

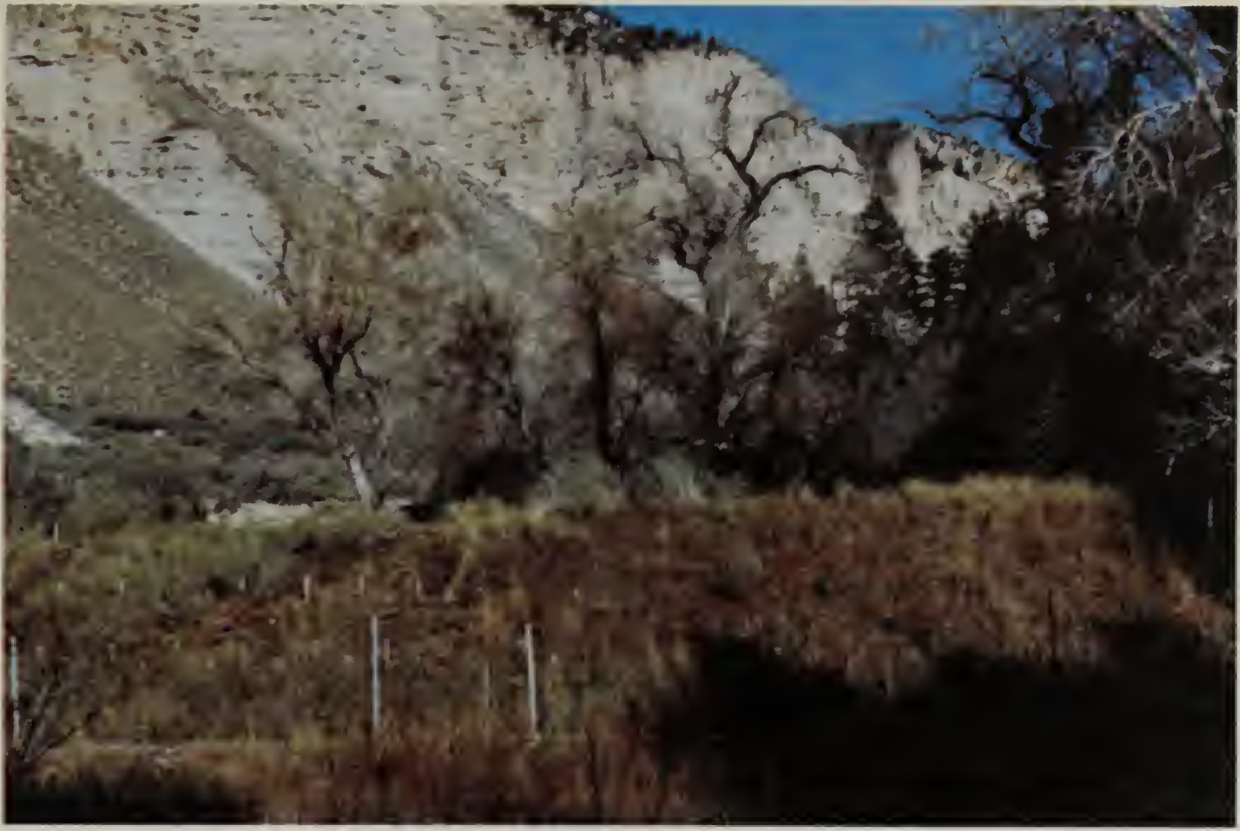


Figure III B-3

VEGETATION AT THE END OF THE 1974 GROWING SEASON (NOVEMBER 1974 PHOTO)

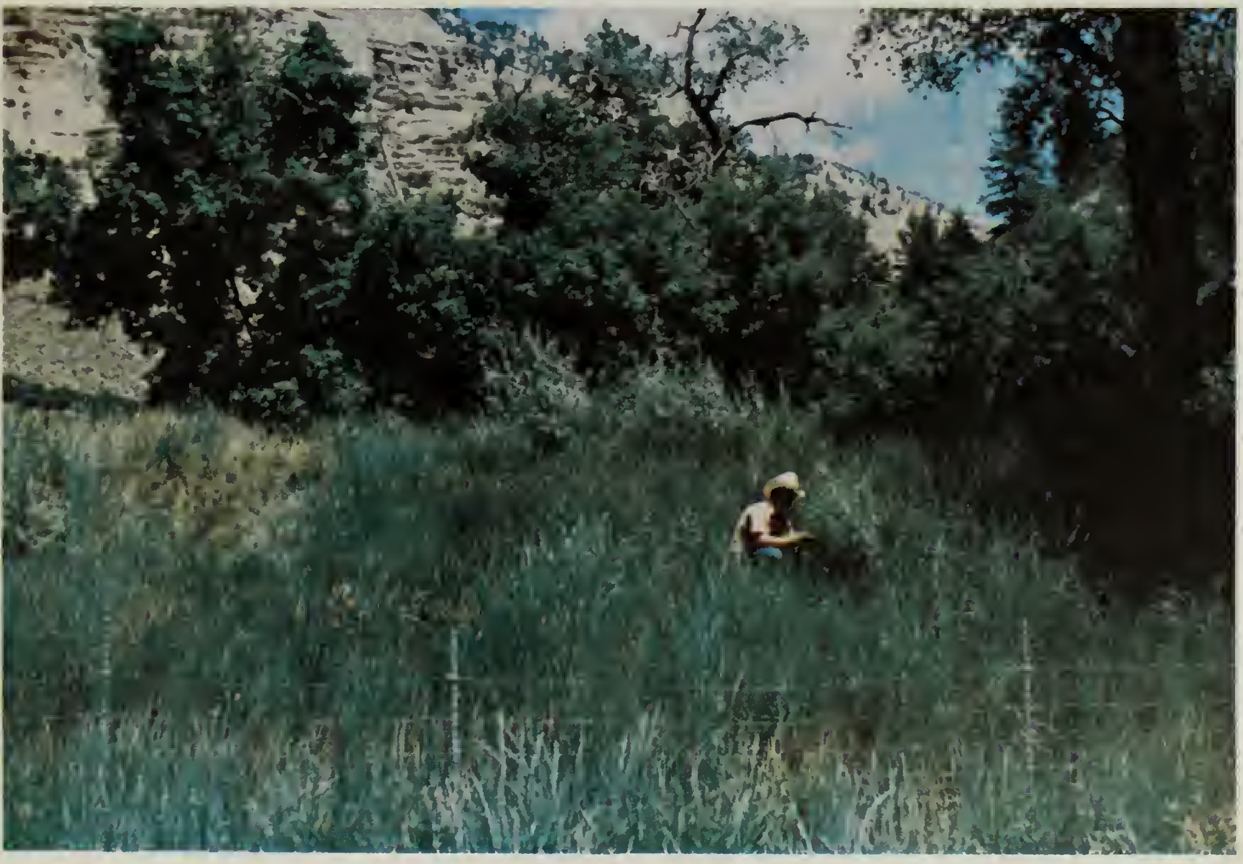
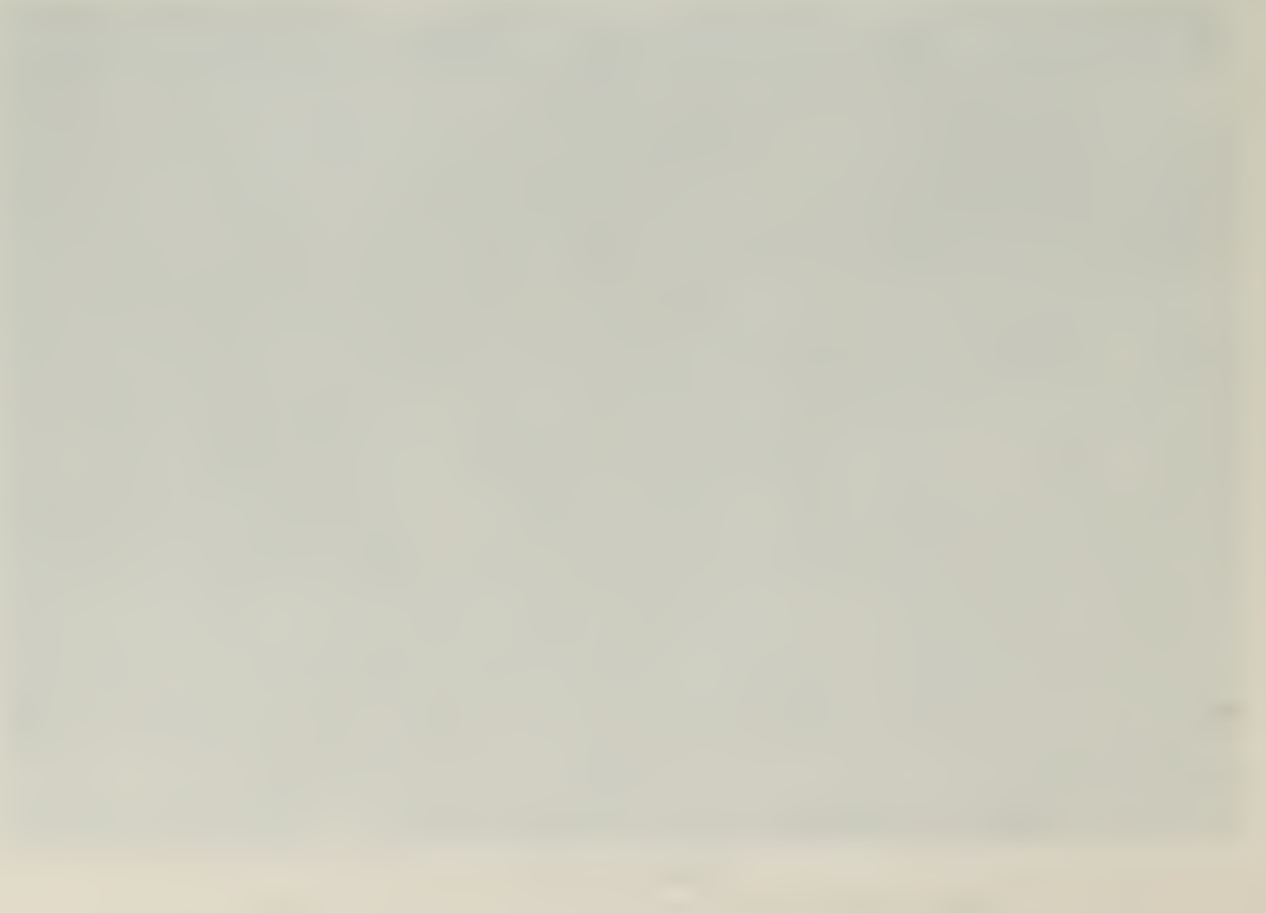


Figure III B-4

GROWTH DURING THE SUMMER OF 1975 (JULY 1975 PHOTO)



III C MICROENVIRONMENTAL PROGRAM

Microenvironmental data collected during the fall and winter months (September, 1975 through February, 1976) are summarized in Tables III C-1 through III C-6. The significant features of this period are the declining temperatures, marking the end of the growing season, and moisture accumulations as snow.

The lowest absolute air temperature during the period was -31°C, recorded in January, 1976. Average temperatures at the ground surface were 18.4°C in September, 12.6°C in October, 0.6°C in November, -0.8°C in December, -2.8°C in January, and -2.2°C in February. Average air temperatures at one meter height were 16.0°C in September, 12.2°C in October, -0.5°C in November, -2.8°C in December, -6.5°C in January, and -2.1°C in February. The maximum recorded surface temperature in September was 47°C. The first hard frost was recorded at both the ground surface and at one meter in September. Free air average minimum temperatures remain above freezing in most sites until November; the first below-freezing temperature in free air was recorded in September.

Total precipitation for the period, based on monthly station averages, was 1.4 cm of moisture falling as rain and snow. The fall months averaged 0.62 cm of moisture, while the winter months averaged 6.4 cm of moisture. September was the driest month of the period at 0.24 cm; January snow accumulations resulted in the greatest moisture for the period at 2.7 cm. Correspondingly, soil moisture continued its declining trend through the fall and increased slowly during the winter months. This trend and the increasing precipitation during winter is evidence of the importance of winter (snow) precipitation to vegetation. This moisture is essentially residual through the winter and becomes available to plants in early spring.

Wind speeds on Tract C-b vary with vegetation type. Wind speed in the upland sagebrush site averaged 8.3 km/hr. These are the strongest winds recorded. Wind speeds in chained rangelands and bottomland sagebrush sites averaged 1.9 km/hr. Average wind speed was lowest in the woodland sites at 1.3 km/hr. Prevailing wind direction in the chained rangelands was southerwesterly. At all other sites winds prevailed from the southeast. Wind speeds increase during the fall and early winter period, peaking in November and December.

Relative humidity values vary between recording locations. Average relative humidity for the fall months was 50% and was 64% for the winter months.

Net radiation values for the period ranged from 0.63 langleys/day in September to 0.36 langleys/day in January, rising in February to 0.42 langleys/day.

Table III C-1

MICROENVIRONMENTAL STATIONS
SEPTEMBER
MONTHLY SUMMARY

STATION NUMBER	SOIL TEMPERATURE °C			AIR TEMPERATURE °C					SOIL MOISTURE %			PRECIPITATION, Total cm*	RELATIVE HUMIDITY, %	WIND SPEED MPH		WIND DIRECTION °Azimuth		NET SOLAR RADIATION, Langleys	VEGETATION TYPE AND LOCATION
	-60 cm	-40 cm	-20 cm	0 cm	1 meter	3 meters	Minimum, Absolute	Maximum, Absolute	-60 cm	-40 cm	-20 cm			1 meter	3 meters	1 meter	3 meters		
1	▨	▨	16.0	▨	▨	▨	-2	35	▨	▨	31	0.08	94	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #1)
2	▨	▨	19.5	▨	▨	▨	-3	39	▨	▨	25	0.20	49	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #2)
3@	28.0	( )	16.0	29.4	27.6	▨	-2	30	40	45	30	1.19	90	5.56	▨	135	▨	▨	UPLAND SAGEBRUSH (Vegetation Plot #3)
4@	16.6	17.4	17.59	15.6	14.2	▨	-5	41	27	28	23	0.36	32	1.98	▨	160	▨	▨	BOTTOM LAND SAGEBRUSH (Vegetation Plot #4)
5	▨	▨	17.0	▨	▨	▨	0	36	▨	▨	21	0.13	76	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #5)
6@	13.4	13.5	13.7	14.2	10.3	▨	3	36	42	43	39	0.61	43	1.43	▨	161	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #6)
7@	( )	15.0	14.8	14.2	11.7	( )	-9	45	56	46	28	0.00	41	1.27	( )	204	( )	.63	CHAINED PINYON-JUNIPER RANGELAND (Animal Trapping Grid #1)
8	▨	▨	23.0	▨	▨	▨	0	37	▨	21	21	0.00	33	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (South-Facing Slope)
9	▨	▨	21.0	▨	▨	▨	6	47	20	19	12	0.86	37	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Mouth of Sorghum Gulch)
10	▨	▨	20.0	▨	▨	▨	-4	41	25	26	22	0.43	44	▨	▨	▨	▨	▨	RABBITBRUSH COMMUNITY (Mouth of West Stewart Gulch)
11	▨	▨	17.5	▨	▨	▨	0	37	▨	▨	14	0.00	47	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (West-Facing Talus Slope)
12	▨	▨	18.0	▨	▨	▨	-3	39	25	25	22	0.10	34	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Alluvial Site)
13	▨	▨	15.5	▨	▨	▨	3	35	( )	34	32	0.03	38	▨	▨	▨	▨	▨	MIXED MOUNTAIN SHRUBLAND (North-Facing Slope)
14	▨	▨	16.0	▨	▨	▨	0	35	31	34	30	0.05	75	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (West-Facing Slope)
15	▨	▨	14.5	▨	▨	▨	0	36	▨	29	25	0.03	50	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Cottonwood Gulch)
16	▨	▨	18.0	▨	▨	▨	-1	39	34	32	30	0.00	62	▨	▨	▨	▨	▨	UPLAND SAGEBRUSH (Head of Sorghum Gulch)
17	▨	▨	29.0	▨	▨	▨	( )	( )	( )	( )	( )	0.00	39	▨	▨	▨	▨	▨	ANNUAL WEED COMMUNITY (Abandoned Drill Pad)

@ Continuous Recording Stations
* Precipitation Values Are Totals For Period, Minimum And Maximum Temperature Values Are Absolute; All Other Values Are Expressed As Means
▨ Values Not Measured At These Stations
() Values Not Available For This Period Due To Instrument Failure

Table III C-2

MICROENVIRONMENTAL STATIONS
OCTOBER
MONTHLY SUMMARY

STATION NUMBER	SOIL TEMPERATURE °C			AIR TEMPERATURE °C					SOIL MOISTURE %			PRECIPITATION, Total cm*	RELATIVE HUMIDITY, %	WIND SPEED MPH		WIND DIRECTION °Azimuth		NET SOLAR RADIATION, Langleys	VEGETATION TYPE AND LOCATION
	-60 cm	-40 cm	-20 cm	0 cm	1 meter	3 meters	Minimum, Absolute	Maximum, Absolute	-60 cm	-40 cm	-20 cm			1 meter	3 meters	1 meter	3 meters		
1	▨	▨	( )	▨	▨	▨	2	30	▨	▨	31	0.43	85	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #1)
2	▨	▨	( )	▨	▨	▨	9	31	▨	▨	25	0.41	63	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #2)
3@	22.1	( )	20.9	19.9	20.6	▨	0	8	38	42	40	0.46	92	5.09	▨	142	▨	▨	UPLAND SAGEBRUSH (Vegetation Plot #3)
4@	( )	( )	( )	( )	( )	▨	11	33	28	28	27	0.50	77	( )	▨	( )	▨	▨	BOTTOM LAND SAGEBRUSH (Vegetation Plot #4)
5	▨	▨	( )	▨	▨	▨	1	32	▨	▨	22	0.10	91	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #5)
6@	10.4	9.8	9.2	9.7	7.8	▨	1	27	38	38	34	0.48	59	1.25	▨	174	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #6)
7@	( )	11.0	9.4	8.2	8.1	( )	-7	30	53	46	25	( )	51	2.02	( )	189	( )	.53	CHAINED PINYON-JUNIPER RANGELAND (Animal Trapping Grid #1)
8	▨	▨	( )	▨	▨	▨	5	38	▨	19	13	0.00	51	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (South-Facing Slope)
9	▨	▨	( )	▨	▨	▨	-10	30	21	21	18	0.43	77	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Mouth of Sorghum Gulch)
10	▨	▨	( )	▨	▨	▨	12	32	25	24	21	0.43	82	▨	▨	▨	▨	▨	RABBITBRUSH COMMUNITY (Mouth of West Stewart Gulch)
11	▨	▨	( )	▨	▨	▨	8	32	▨	▨	14	0.00	69	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (West-Facing Talus Slope)
12	▨	▨	( )	▨	▨	▨	12	33	26	25	22	0.48	81	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Alluvial Site)
13	▨	▨	( )	▨	▨	▨	10	30	35	33	31	0.66	62	▨	▨	▨	▨	▨	MIXED MOUNTAIN SHRUBLAND (North-Facing Slope)
14	▨	▨	( )	▨	▨	▨	-7	38	30	33	26	0.13	63	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (West-Facing Slope)
15	▨	▨	( )	▨	▨	▨	-9	30	▨	29	26	0.20	64	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Cottonwood Gulch)
16	▨	▨	( )	▨	▨	▨	8	29	31	31	29	0.46	88	▨	▨	▨	▨	▨	UPLAND SAGEBRUSH (Head of Sorghum Gulch)
17	▨	▨	( )	▨	▨	▨	10	29	( )	( )	( )	0.00	94	▨	▨	▨	▨	▨	ANNUAL WEED COMMUNITY (Abandoned Drill Pad)

@ Continuous Recording Stations

* Precipitation Values Are Totals For Period, Minimum And Maximum Temperature Values Are Absolute; All Other Values Are Expressed As Means

▨ Values Not Measured At These Stations

() Values Not Available For This Period Due To Instrument Failure

Table III C-3

MICROENVIRONMENTAL STATIONS

NOVEMBER
MONTHLY SUMMARY

STATION NUMBER	SOIL TEMPERATURE °C			AIR TEMPERATURE °C					SOIL MOISTURE %			PRECIPITATION, Total cm*	RELATIVE HUMIDITY, %	WIND SPEED MPH		WIND DIRECTION °Azimuth		NET SOLAR RADIATION, Langleys	VEGETATION TYPE AND LOCATION
	-60 cm	-40 cm	-20 cm	0 cm	1 meter	3 meters	Minimum, Absolute	Maximum, Absolute	-60 cm	-40 cm	-20 cm			1 meter	3 meters	1 meter	3 meters		
1	▨	▨	2.0	▨	▨	▨	-12	25	▨	▨	39	0.76	24	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #1)
2	▨	▨	6.5	▨	▨	▨	-9	26	▨	▨	42	1.42	21	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #2)
3@	( )	( )	1.0	( )	( )	▨	-19	18	45	42	37	1.27	37	5.48	▨	141	▨	▨	UPLAND SAGEBRUSH (Vegetation Plot #3)
4@	6.4	4,7	3,2	0,9	0.5	▨	-10	28	27	30	44	1.14	36	1.84	▨	157	▨	▨	BOTTOM LAND SAGEBRUSH (Vegetation Plot #4)
5	▨	▨	5.0	▨	▨	▨	-13	22	▨	▨	27	2.49	23	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #5)
6@	6.2	4.7	3.6	2.9	2.4	▨	-11	22	39	45	45	3.07	20	1.19	▨	167	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #6)
7@	( )	3.4	4.6	-1.9	-4.5	(-)	-13	25	46	46	45	( )	19	3.35	(-)	212	(-)	.35	CHAINED PINYON-JUNIPER RANGELAND (Animal Trapping Grid #1)
8	▨	▨	12.0	▨	▨	▨	-4	31	▨	20	18	0.00	20	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (South-Facing Slope)
9	▨	▨	4.5	▨	▨	▨	-16	29	19	21	32	0.97	26	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Mouth of Sorghum Gulch)
10	▨	▨	2.3	▨	▨	▨	-10	24	26	25	35	1.32	37	▨	▨	▨	▨	▨	RABBITBRUSH COMMUNITY (Mouth of West Stewart Gulch)
11	▨	▨	2,3	▨	▨	▨	-17	26	▨	▨	33	0.00	20	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (West-Facing Talus Slope)
12	▨	▨	2.8	▨	▨	▨	-19	29	26	25	45	1.57	19	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Alluvial Site)
13	▨	▨	0.3	▨	▨	▨	-15	23	( )	35	46	1.50	22	▨	▨	▨	▨	▨	MIXED MOUNTAIN SHRUBLAND (North-Facing Slope)
14	▨	▨	1.3	▨	▨	▨	-14	26	31	32	46	2.92	25	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (West-Facing Slope)
15	▨	▨	0.0	▨	▨	▨	-9	51	▨	33	43	0.90	23	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Cottonwood Gulch)
16	▨	▨	2.0	▨	▨	▨	-10	24	31	29	46	1.32	24	▨	▨	▨	▨	▨	UPLAND SAGEBRUSH (Head of Sorghum Gulch)
17	▨	▨	6.3	▨	▨	▨	-21	41	( )	( )	( )	0.00	23	▨	▨	▨	▨	▨	ANNUAL WEED COMMUNITY (Abandoned Drill Pad)

@ Continuous Recording Stations

* Precipitation Values Are Totals For Period, Minimum And Maximum Temperature Values Are Absolute; All Other Values Are Expressed As Means

▨ Values Not Measured At These Stations

() Values Not Available For This Period Due To Instrument Failure

Table III C-4

MICROENVIRONMENTAL STATIONS

DECEMBER 1975
MONTHLY SUMMARY

STATION NUMBER	SOIL TEMPERATURE °C			AIR TEMPERATURE °C					SOIL MOISTURE %			PRECIPITATION, Total cm*	RELATIVE HUMIDITY, %	WIND SPEED MPH		WIND DIRECTION °Azimuth		NET SOLAR RADIATION, Langleys	VEGETATION TYPE AND LOCATION
	-60 cm	-40 cm	-20 cm	0 cm	1 meter	3 meters	Minimum, Absolute	Maximum, Absolute	-60 cm	-40 cm	-20 cm			1 meter	3 meters	1 meter	3 meters		
1	▨	▨	( )	▨	▨	▨	-23	19	▨	▨	75	1.15	59	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #1)
2	▨	▨	( )	▨	▨	▨	-25	18	▨	▨	61	1.35	50	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #2)
3@	3.1	( )	2.0	0.2	-4.5	▨	-11.5	2.5	41	48	62	1.15	70	5.83	▨	137	▨	▨	UPLAND SAGEBRUSH (Vegetation Plot #3)
4@	4.0	2.2	1.0	0.5	-2.3	▨	-23.0	15.0	30	32	55	1.52	42	1.68	▨	118	▨	▨	BOTTOM LAND SAGEBRUSH (Vegetation Plot #4)
5	▨	▨	( )	▨	▨	▨	-20	17	▨	▨	( )	1.10	70	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #5)
6@	1.6	0.5	-0.8	-2.7	-2.3	▨	-13.0	7.5	40	47	70	1.37	57	2.24	▨	158	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #6)
7@	( )	2.6	0.3	-1.2	-2.1	( )	-19.3	12.8	46	47	57	( )	70.1	1.36	( )	205	( )	.41	CHAINED PINYON-JUNIPER RANGELAND (Animal Trapping Grid #1)
8	▨	▨	( )	▨	▨	▨	-18	26	▨	25	10	( )	32	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (South-Facing Slope)
9	▨	▨	( )	▨	▨	▨	-26	21	22	22	37	1.50	59	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Mouth of Sorghum Gulch)
10	▨	▨	( )	▨	▨	▨	-28	21	28	27	50	1.50	39	▨	▨	▨	▨	▨	RABBITBRUSH COMMUNITY (Mouth of West Stewart Gulch)
11	▨	▨	( )	▨	▨	▨	-24	17	▨	▨	53	1.25	55	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (West-Facing Talus Slope)
12	▨	▨	( )	▨	▨	▨	-28	21	27	26	49	1.35	42	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Alluvial Site)
13	▨	▨	( )	▨	▨	▨	-23	15	39	41	54	1.65	62	▨	▨	▨	▨	▨	MIXED MOUNTAIN SHRUBLAND (North-Facing Slope)
14	▨	▨	( )	▨	▨	▨	-22	20	32	35	43	0.94	73	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (West-Facing Slope)
15	▨	▨	( )	▨	▨	▨	-25	30	▨	35	62	1.45	73	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Cottonwood Gulch)
16	▨	▨	( )	▨	▨	▨	-24	28	35	33	48	1.90	66	▨	▨	▨	▨	▨	UPLAND SAGEBRUSH (Head of Sorghum Gulch)
17	▨	▨	( )	▨	▨	▨	-29	16	22	27	56	( )	64	▨	▨	▨	▨	▨	ANNUAL WEED COMMUNITY (Abandoned Drill Pad)

@ Continuous Recording Stations
* Precipitation Values Are Totals For Period, Minimum And Maximum Temperature Values Are Absolute; All Other Values Are Expressed As Means
▨ Values Not Measured At These Stations
() Values Not Available For This Period Due To Instrument Failure

Table III C-5

MICROENVIRONMENTAL STATIONS
JANUARY 1976
MONTHLY SUMMARY

STATION NUMBER	SOIL TEMPERATURE °C			AIR TEMPERATURE °C					SOIL MOISTURE %			PRECIPITATION, Total cm*	RELATIVE HUMIDITY, %	WIND SPEED MPH		WIND DIRECTION °Azimuth		NET SOLAR RADIATION, Langleys	VEGETATION TYPE AND LOCATION
	-60 cm	-40 cm	-20 cm	0 cm	1 meter	3 meters	Minimum, Absolute	Maximum, Absolute	-60 cm	-40 cm	-20 cm			1 meter	3 meters	1 meter	3 meters		
1	▨	▨	( )	▨	▨	▨	-24	15	▨	▨	80	3.9	( )	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #1)
2	▨	▨	( )	▨	▨	▨	-22	18	▨	▨	72	3.4	( )	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #2)
3•	2.2	-12.8	0.8	-0.6	-0.6	▨	-23.5	5.5	41	52	68	4.15	( )	4.12	▨	130	▨	▨	UPLAND SAGEBRUSH (Vegetation Plot #3)
4•	2.0	0.2	-1.3	-2.0	-5.8	▨	-28.0	13.0	30	31	54	2.29	( )	2.26	▨	136	▨	▨	BOTTOM LAND SAGEBRUSH (Vegetation Plot #4)
5	▨	▨	( )	▨	▨	▨	-26	10	▨	▨	65	4.3	( )	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #5)
6•	-0.4	-1.5	-2.8	-5.1	-6.7	▨	-19.0	4.5	40	44	72	2.20	( )	1.30	▨	173	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #6)
7•	( )	0.7	-1.8	-3.4	-7.6	( )	-28.7	5.5	53	48	63	2.2	66	2.02	( )	211	( )	.36	CHAINED PINYON-JUNIPER RANGELAND (Animal Trapping Grid #1
8	▨	▨	( )	▨	▨	▨	-18	10	▨	25	45	1.1	( )	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (South-Facing Slope)
9	▨	▨	( )	▨	▨	▨	-31	11	22	21	31	2.0	( )	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Mouth of Sorghum Gulch)
10	▨	▨	( )	▨	▨	▨	-22	28	28	27	47	2.7	( )	▨	▨	▨	▨	▨	RABBITBRUSH COMMUNITY (Mouth of West Stewart Gulch)
11	▨	▨	( )	▨	▨	▨	-27	10	▨	▨	61	( )	( )	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (West-Facing Talus Slope)
12	▨	▨	( )	▨	▨	▨	-24	14	27	25	45	1.9	( )	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Alluvial Site)
13	▨	▨	( )	▨	▨	▨	-16	8	( )	38	45	3.1	( )	▨	▨	▨	▨	▨	MIXED MOUNTAIN SHRUBLAND (North-Facing Slope)
14	▨	▨	( )	▨	▨	▨	-29	15	31	35	41	1.7	( )	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (West-Facing Slope)
15	▨	▨	( )	▨	▨	▨	-22	10	▨	59	64	3.5	( )	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Cottonwood Gulch)
16	▨	▨	( )	▨	▨	▨	-16	8	35	34	54	12.7	( )	▨	▨	▨	▨	▨	UPLAND SAGEBRUSH (Head of Sorghum Gulch)
17	▨	▨	( )	▨	▨	▨	-25	9	22	26	64	2.4	( )	▨	▨	▨	▨	▨	ANNUAL WEED COMMUNITY (Abandoned Drill Pad)

• Continuous Recording Stations
* Precipitation Values Are Totals For Period, Minimum And Maximum Temperature Values Are Absolute; All Other Values Are Expressed As Means
▨ Values Not Measured At These Stations
() Values Not Available For This Period Due To Instrument Failure

Table III C-6

MICROENVIRONMENTAL STATIONS
FEBRUARY 1976
MONTHLY SUMMARY

STATION NUMBER	SOIL TEMPERATURE °C			AIR TEMPERATURE °C					SOIL MOISTURE %			PRECIPITATION, Total cm*	RELATIVE HUMIDITY, %	WIND SPEED MPH		WIND DIRECTION °Azimuth		NET SOLAR RADIATION, Langleys	VEGETATION TYPE AND LOCATION
	-60 cm	-40 cm	-20 cm	0 cm	1 meter	3 meters	Minimum, Absolute	Maximum, Absolute	-60 cm	-40 cm	-20 cm			1 meter	3 meters	1 meter	3 meters		
1	▨	▨	( )	▨	▨	▨	-23	16	▨	▨	81	( )	( )	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #1)
2	▨	▨	( )	▨	▨	▨	-19	4	▨	▨	88	( )	( )	▨	▨	▨	▨	▨	CHAINED PINYON-JUNIPER RANGELAND (Vegetation Plot #2)
3@	1.2	-12.5	0.0	-0.7	-0.8	▨	-16.5	12.5	40	46	58	4.60	( )	5.09	▨	130	▨	▨	UPLAND SAGEBRUSH (Vegetation Plot #3)
4@	1.0	-0.3	-1.0	-1.7	-1.4	▨	-20.5	15.5	30	30	39	2.48	( )	1.65	▨	135	▨	▨	BOTTOM LAND SAGEBRUSH (Vegetation Plot #4)
5	▨	▨	( )	▨	▨	▨	-20	11	▨	▨	77	3.09	( )	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #5)
6@	-1.3	-2.1	-2.9	-4.0	-3.3	▨	-18.5	10.5	40	42	57	0.99	( )	0.87	▨	157	▨	▨	PINYON-JUNIPER WOODLAND (Vegetation Plot #6)
7@	( )	-4.0	-2.1	-2.3	-2.6	( )	-20.1	11.9	54	50	52	1.41	68.1	1.51	( )	21	( )	.42	CHAINED PINYON-JUNIPER RANGELAND (Animal Trapping Grid #1)
8	▨	▨	( )	▨	▨	▨	-23	21	▨	25	35	0.64	( )	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (South-Facing Slope)
9	▨	▨	( )	▨	▨	▨	-26	13	22	22	24	4.19	( )	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Mouth of Sorghum Gulch)
10	▨	▨	( )	▨	▨	▨	-26	14	29	29	29	1.89	( )	▨	▨	▨	▨	▨	RABBITBRUSH COMMUNITY (Mouth of West Stewart Gulch)
11	▨	▨	( )	▨	▨	▨	-26	11	▨	▨	78	1.65	( )	▨	▨	▨	▨	▨	BUNCHGRASS COMMUNITY (West-Facing Talus Slope)
12	▨	▨	( )	▨	▨	▨	-21	12	27	27	30	2.21	( )	▨	▨	▨	▨	▨	BOTTOM LAND SAGEBRUSH (Alluvial Site)
13	▨	▨	( )	▨	▨	▨	-21	10	( )	39	44	2.59	( )	▨	▨	▨	▨	▨	MIXED MOUNTAIN SHRUBLAND (North-Facing Slope)
14	▨	▨	( )	▨	▨	▨	-22	11	31	34	33	2.37	( )	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (West-Facing Slope)
15	▨	▨	( )	▨	▨	▨	-25	7	▨	65	47	( )	( )	▨	▨	▨	▨	▨	PINYON-JUNIPER WOODLAND (Cottonwood Gulch)
16	▨	▨	( )	▨	▨	▨	( )	( )	35	34	55	( )	( )	▨	▨	▨	▨	▨	UPLAND SAGEBRUSH (Head of Sorghum Gulch)
17	▨	▨	( )	▨	▨	▨	-26	10	( )	25	36	( )	( )	▨	▨	▨	▨	▨	ANNUAL WEED COMMUNITY (Abandoned Drill Pad)

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Form 1279–3
(June 1984)

BORROWER'

TN 859 .C64 C37
C-b Shale Oil P
Tract C-b: summ

DATE LOANED	BORROWER

USDI – BLM